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Instruments
THE MAGAZINE OF Measurement and Control

Vol. 14 MARCH 1941 No. 3

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Courtesy Leeds & Northrup Co.

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

"Installation," "Care," "Maintenance" and "Service"

SEVERAL times during the last few years, a sudden increase in the number of inquiries pertaining to some particular topic led to a brief investigation and resulted in one or two editorials—sometimes in a specially-written feature article.

There has been a sudden increase in requests for information on installation, care, maintenance and servicing of industrial instruments—who, when, where, how, etc. These inquiries do not relate merely to physical details. They refer to intangibles and imponderables. They cannot be answered by such advice as "Use watchmakers' oil instead of machine oil," or "Send fifteen cents to the Government Printing Office for Bureau of Standards Circular number so-and-so."

These inquiries stump us, for a helpful answer requires fairly complete knowledge of the facts—and in most cases a statement of the pertinent facts would fill a four-page letter (whereas the usual inquiry is a four-line letter). Convinced as we are that classifications and definitions are the key to useful knowledge, we venture to state two needs:

There is a crying need for general agreement on definitions of the four terms: Installation, Care, Maintenance, and Servicing. Also for better understanding as to the dividing line (or lines) between the maker's and user's responsibility.

At present, however, there are so many groups of instrument manufacturers and instrument users concerned, and they are all so busy (*it's because they're busy that the questions come up*) that it is utterly out of the question to think of holding a convention or symposium, with official delegates, etc.

Besides, there is a double infinity of possible cases: the vendor of the instrument may be a one-man firm or a giant corporation; the user of the instrument ditto. At one extreme we have Bill Jones, who builds (or rather assembles) testing sets in the basement of his dad's house, selling one of these instruments to Joe Smith who has a radio shop around the corner. Toward the other extreme we have, for example, what your editor actually saw four years ago: *carloads* of instruments and meters from several large companies being received at Boulder Dam.

Bill Jones and Joe Smith conduct their negotiations orally and the agreement as to installation, care, maintenance, and servicing probably consists of the following dialogue: "I got her calibrated, Joe. She's right on the nose. Treat her right and she'll never go sour on you. Just remember that zeroing screw."—"Okay, Bill, but if she does go sour you'll have to come an' fix 'er."

The Boulder Dam negotiations probably began years before the delivery of the carloads of instruments and meters, with conferences over blueprints and specifications, and hundreds of typewriters clicking in Washington, Denver, Los Angeles and Boulder City, as well as Newark, Schenectady, and Philadelphia. Receiving, unpacking, transporting to location, and erecting—these labor items alone required crews as large and well-drilled as field-artillery batteries. The story of the installations and initial tests could fill a volume—and no doubt a few parts of this story have filled many pages in technical magazines and official reports. The "maintenance mechanics" (we spoke with several) are in reality junior engineers with high ratings in the Civil Service. The servicing agreements are no doubt longer than insurance policies.

It is between such extremes, however, that the need for clarification is greatest. Neither Joe Smith nor Uncle Sam has asked our advice. The inquiries we receive come from "the middle-class."

It was at the turn of the year that the volume of these inquiries began to grow. By a happy coincidence, the last meeting of the American Society for Measurement and Control was largely devoted to a general discussion of user maintenance and maker servicing. A number of interesting episodes were related; and several interesting situations described. It is not amiss to record here a few of these cases.

Case 1

Related by head of instrument department of a large company where nearly 3000 industrial instruments are in use: "According to company rules, instruments as well as tools, parts, etc., that come in wooden cases are unpacked by the Janitor's department. Instruction sheets get lost. I have asked the instrument companies to always send duplicate sheets by mail but they don't all do it in time. Absence of instructions recently resulted in damage during installation, necessitating shipping the instrument back to the factory for major repairs beyond our facilities."

Case 2

The same member: "Another source of trouble is night crews. Many departments are running twenty-four hours; but not the Instrument Department. I thought that cutting the capillary tubes of recording thermometers was just an amusing fiction until I was called out of bed at 3 a. m. because a night foreman had actually ordered a man to do just that."

Case 3

A member: "Cutting the capillaries of thermometers does happen in more cases than you'd think. Some users, though, are almost afraid to touch instruments. A company near Pittsburgh bought their first recording thermometer and had three service calls because the instrument had stopped recording; and each time, the service man merely had to screw down the lock of the glass door. You see, this was one of those recorders with an automatic pen lifter."

Case 4

Chief instrument engineer of another large company: "The receiving department delivers instruments to our department in their original packing-cases, but our men know so much about instruments that sometimes they scorn reading instructions. When a new and interesting type of instrument comes in, we all monkey with it. I am one of the curious ones. I can't resist the temptation of turning anything that looks like a hex nut. We are so sure of ourselves that factory adjustments don't mean a thing to us: we recalibrate almost everything that comes in. On the whole, this works out fine, but we never can be sure whether any instrument was in good adjustment at the

(Concluded on page 72)

AC-ME RECORDING GRAVITOMETER

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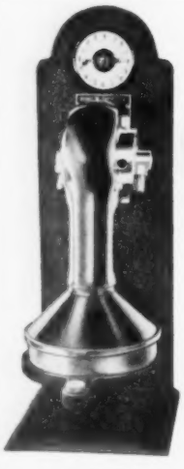

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Rapid and accurate moisture test in percentage by drying. Drying temperature controlled by thermostat. Ideal for plant moisture control or laboratory moisture determinations.

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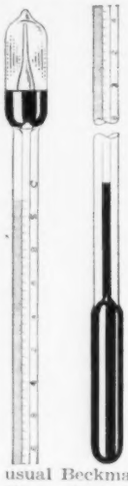
THE MONTH'S NEW INSTRUMENTS

In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control.

When writing to manufacturers directly, please mention this department as your source of information. Or write to Information Section, Instruments Publishing Company.

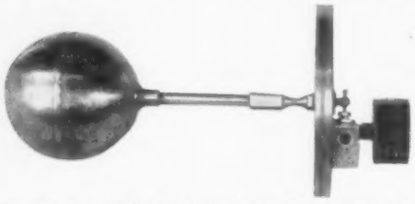
"Thousandth-of-a-degree" Beckmann Thermometer



Viscosity measurements, calorimetry and determinations of freezing or boiling points of commercial products frequently call for reading temperatures to a thousandth of a degree. This sensitivity is attained in a new design of Beckmann or variable-setting type. Scale covers 5°C. subdivided to hundredths and the reading may be estimated to thousandths with a magnifier. Construction differs from that of the rather fragile Beckmann thermometer in that new instrument has a solid stem and, except for setting device at top, closely resembles the usual laboratory thermometer. Setting device is said to be simply constructed and easy to use. Due to smaller bulb, lag is considerably shorter than in usual Beckmann type. Etched-stem construction eliminates uncertainties. Lens-front stem tubing facilitates readings.—*Philadelphia Thermometer Co., 915 Filbert St., Philadelphia, Pa.*

Float-type Liquid Level Controllers

Design of new "Moore Liquid Level Controller" obviates need for packing glands, pressure-tight shafts or electrical system for transmitting motion through the wall of a

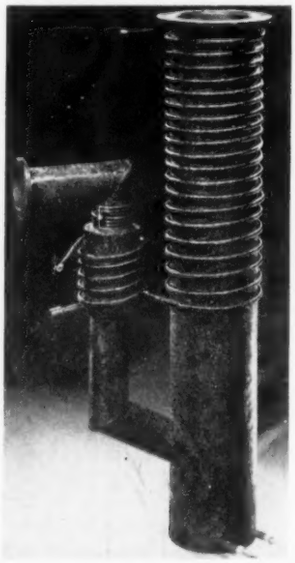


pressure vessel to atmosphere. Essential elements: a 4" diam. float and shaft connected to a flattened member, similar to a Bourdon tube, which is fastened to a supporting

flange. A flat lever inside this tube and fastened to the float shaft end actuates air pilot or micro-switch for controlling liquid level. A change in buoyant force on the float flexes the flattened tube and through the flat lever transmits the float motion to atmospheric pressure. Sensitivity: a change in level of ½" of water will result in a full 15 lbs./in.^{2} change of transmitted control pressure. Flexing of flattened tube is at all times within its elastic limit and tests have shown that with a special float the equipment will operate at 5000 lbs./in.^{2} pressure with only about a 20% reduction in sensitivity. By using slightly larger weighted floats this controller is used successfully for interface level control where difference in specific gravity is as low as 0.07. Materials used may be changed to suit corrosive liquids and since there are no rotating or sliding parts, all exposed surfaces may be silver- or gold-plated, or rubber-covered to resist action of various chemicals.—*Moore Products Co., 3629 N. Lawrence St., Philadelphia, Pa.*

Fractionating Pump

New all-metal fractionating pump, "Type MC-275," added to maker's line of high-vacuum equipment, is a vertical unit developed specifically to meet needs of indus-



trial fields in which a more rugged pump than the well-known glass-metal type is required. All-metal construction guards against accidental breakage. Pump can easily be adapted to fit most vacuum systems. Extremely high speeds (nearly 200 liters per second) are available in the range of 10^{-3} to 10^{-5} mm. of Hg. This high speed, coupled with the ultimate vacuum rating of 6×10^{-6} mm., fits pump for use with high-vacuum apparatus and in mirror coating, metal sputtering, lens coating, etc. Although not of multistage type, unit is a fractional model due to its catchment lobe on the forepressure arm. Special rugged esters are used as pumping fluid.—*Distillation Products, Inc., Rochester, N. Y.*

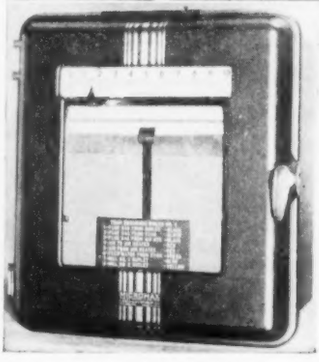
Portable Hardness Tester

New "Impressor" is a pocket-size hardness tester for aluminum alloys or similar soft metals, plastics, hard rubber, etc. It permits testing finished parts of almost

any size or shape. A slight pressure against the surface to be tested is said to give an instantaneous direct reading. No experience in the use of this instrument is necessary, and accuracy is not affected by operator. Impressor may be used in any position (even inverted) thus making it possible to check hardness of vital points after parts have been fabricated in finished assemblies. —*Barber-Colman Co., Rockford, Ill.*

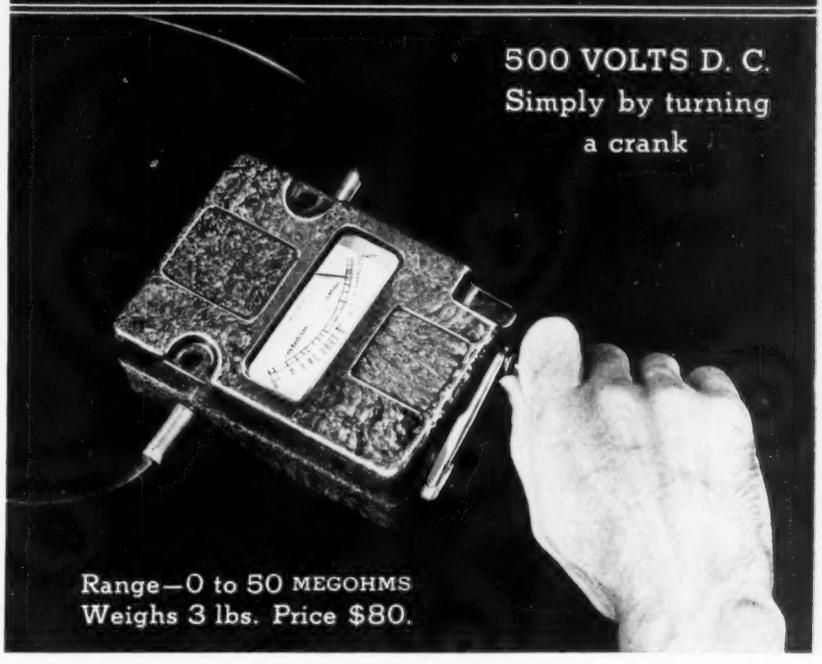
Daily Tear-off Device for Strip-chart Recorders

New daily tear-off device for "Micromax" strip-chart recorders enables users of these recorders to tear off and file a record of each day's operation. It is said that



the device can be quickly and easily attached. When it is used, there is no wasted chart, and it is not necessary to rethread chart through guides. A rubber stamp can be furnished which identifies recorder and location of thermocouples.—*Leeds & Northrup Co., 4984 Stenton Ave., Philadelphia, Pa.*

MIDGET "MEGGER"
TRADE MARK REGISTERED U.S. PAT. OFF.
INSULATION TESTER



Protection Against Electrical Breakdowns

Here is a testing device that should be used today by every maintenance man who is seriously interested in forestalling electrical failures. Detects dirt, moisture and deterioration in the insulation of practically all types of electrical equipment. No batteries or any "adjustments." Independent of all external current. Simply turn the crank; read the scale. Can be carried in pocket or tool kit and is ready for use *any time* and *any where*.

"Meg" Insulation Tester
"Megger" instruments of this type have ranges up to 2000 megohms with hand generators up to 1000 volts.

Our Midget "Megger" Tester as well as other types of hand-driven and motor-driven "Megger" Insulation Testing Instruments is described in new Catalog 1685-I just issued. Write for copy.

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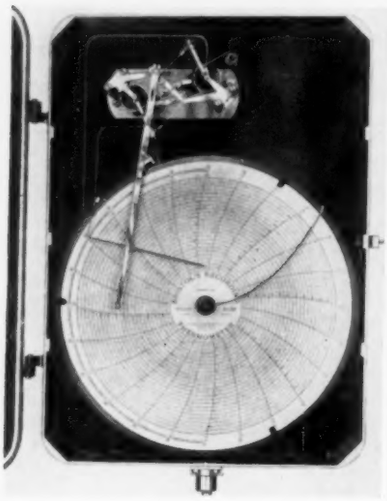
1211-13 ARCH STREET *Electrical and Scientific Instruments* PHILADELPHIA, PA.

Recording Thermometers

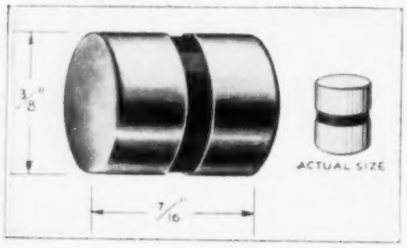
Two new types of recording thermometers of the liquid-filled class have been added to maker's line of round-chart instruments. They will be known as the "Case-Compen-



sated Class I" Recording Thermometer and the "Fully-Compensated Class I" Recording Thermometer. Improved design and construction of the measuring elements, tubing, and bulbs in these instruments are said to extend the field of application of the liquid-filled thermometer, making it possible to take advantage of the desirable characteristics of the "Class I" thermometer system on a greater variety of temperature-measuring problems. The case-compensated instrument is offered in temperature ranges up to 400°F. and tubing lengths up to 10 feet or longer depending on conditions surrounding the installation. The fully-compensated thermometer may be had in ranges up to 400°F. equipped with 200 feet or less of connecting tubing between instrument and bulb. These thermometers are said to have higher sensitivity and accuracy. Improved design measuring element is considerably stronger and more powerful than previous designs. Variations in temperature along tubing and in case do not impair accuracy. The measuring systems of these thermometers are also used in maker's Free-Vane Air-Operated Temperature Controller.—*The Bristol Co., Waterbury, Conn.*

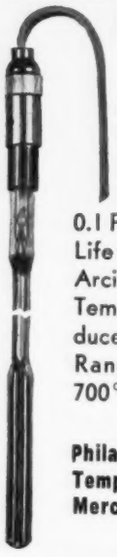
Mercury Midget Switch

A new extremely-small mercury switch (7/16" long, 3/8" diam.) is designed for use in low-voltage circuits up to 25 volts a.c. or d.c., and currents up to 10 amps. at 6 volts and 3 amps. at 25 volts. There is no friction or wear in operation, and no main-



tenance or attention is required. The durable metal and Bakelite body contains the mercury. A newly designed baffle device assures positive "make or break" operation, with no opportunity for a flickering action when equipment is jolted, it is said. Switch is designed for circuits of thermostats, telephones, indicators, for automobile glove compartment and trunk lights, door lights, etc.—*Littelfuse, Inc., 4748 N. Ravenswood Ave., Chicago, Ill.*

Philadelphia Merc-to-Merc Thermo-Regulators Feature



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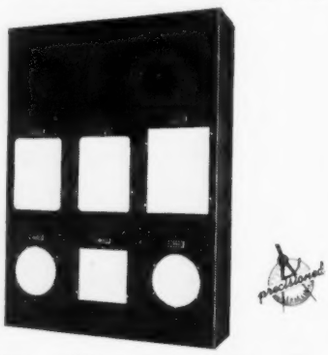

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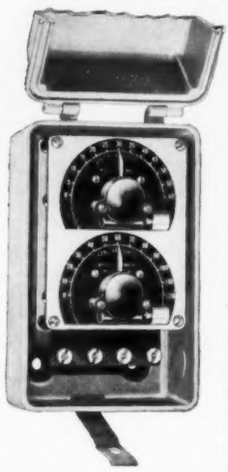
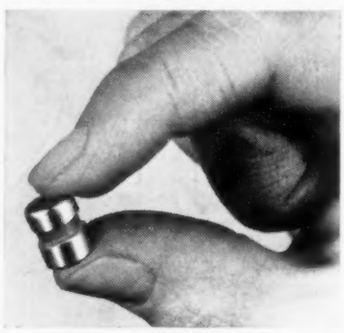
Double-reset Timers

New Automatic Double-Reset Timers have been designed for industrial applications requiring an adjustable and rapidly-repeating time cycle. They incorporate improvements recently announced for maker's Time Delay Relays and Reset Timers as described in several recent issues of *Instruments*. New twin unit consists of two reset timer mechanisms mounted upon a control panel and controlling common electrical circuits. Both have the same adjustments and "band-spread" time scales. Gray enameled die-cast housing is dust-proof, facilitating mounting and wiring. Either conduit or BX type wiring may be used. Housing may be locked as protection against alteration of timing of industrial processes. Operation may be described by a typical use: furnishing a 10-second impulse every 90 seconds for signalling or heating control purposes. For this, a 120- and a 15-second timer are combined; one timer is set to close the control circuit in 90 seconds; the other is set for 10 seconds. Switching arrangement of the entire instrument can be used as a s-p. d-t. switch. Once the unit has been energized, first timer closes control circuit at end of 90 seconds; second timer then operates simultaneously with delivery of desired impulse for a period of 10 seconds. First timer has meanwhile reset and is again put into operation at end of the 10-second interval when second timer opens control circuit and cuts off the impulse. The 90-second interval then recurs. This continues until external control switch is opened. New Double-Reset Timers are furnished for 110- or 220-volt and 50- or 60-cycle operation. Time ranges available for each of the individual timers are 15, 30, 60 and 120 seconds, maximum. Current carrying capacity of the switches is 10 amperes at 110 volts 60 cycles. Housing dimensions are 7 5/8" × 4 3/4" × 3 3/4". Knockouts for 3/4" and 1/2" conduit are provided. —*R. W. Cramer Co., Centerbrook, Conn.*



Mercury Switches

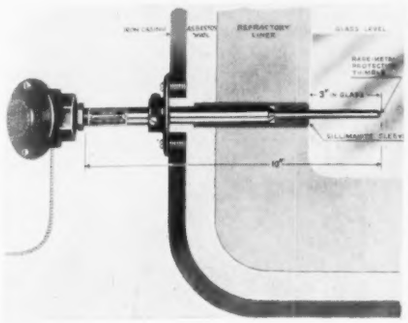
New "all-metal" mercury switch is designated the "Tipit" Switch. Illustration shows "Tiny Tipit" which has a capacity of 1/2 amp. at 24 volts to 4 amps. at 6 volts.



Among uses are under-the-hood illumination, glove compartment lighting, infrequent operation of a low-watt circuit, explosive atmospheres, etc. Switch mounts in a small holder with screw stakes for terminal connection. This assembly is attached to door, lid, or other movable member. Switch operates on a tilt of 20° or more.—*Durakool, Inc., 1010 N. Main St., Elkhart, Ind.*

Thermocouple for Molten Glass

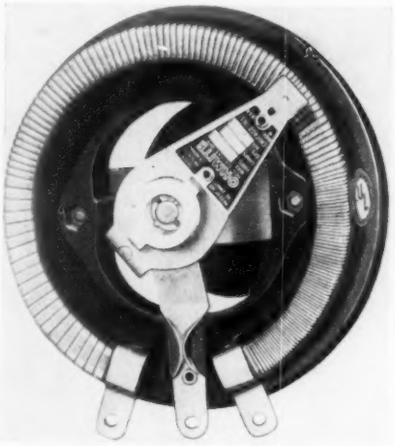
New Deep-immersion Thermocouple for molten glass represents ten years of research and field tests of successive designs, with four main objectives: (1) to measure



glass temperature where there is an actual flow of glass through spout orifice rather than in stagnant mass at side walls; (2) measuring element rigidly located and not liable to be bent or damaged by glass flow or by floating brickwork; (3) avoid contamination of glass; (4) thermocouples to be readily and safely removable and portable. Although primarily developed for feeders, newly announced assembly is suitable for glass pots or tanks. Illustration brings out main outward features. Thermocouple wires are rare-metal, with their measuring-junction tip grounded against end of rare-metal sheath to minimize thermal lag. — *Brown Instrument Co., 4482 Wayne Ave., Philadelphia, Pa.*

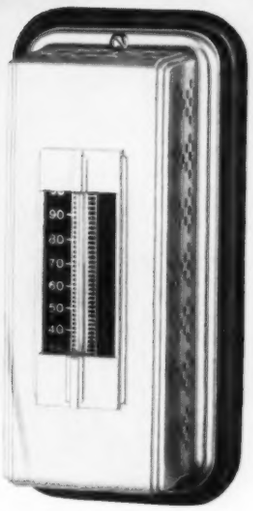
Generator Field Rheostats

Use of new generator field control rheostats is said to accomplish close control of generator voltage and to simplify design problems for generator and switchboard de-



signers. By providing practically continuous variation of resistance in even the smallest sizes, new rheostats are said to effect considerable saving in control-panel space: particularly useful on portable equipment, such as welding generators, home lighting plant generators, etc., also on shipboard, trains, planes, etc. New rheostats are tapered or uniformly wound, as required, designed to provide control for separately- or self-excited generators. They are available in hundreds of standard size units, from 25 to 1000 watts and from 24-32 volts to 320-400 volts. By connecting rheostats in tandem, this range can be extended further.—*Ohmite Manufacturing Co., 4835 Flournoy St., Chicago, Ill.*

GRADUAL CONTROL THAT IS G-R-A-D-U-A-L



Johnson Room Thermostat with adjustable sensitivity. Eliminates "hunting" and departure from control point.

Johnson "Absolute-positioning" pilot operated Damper Motors with two diaphragms, insuring precise positioning of dampers. No springs.

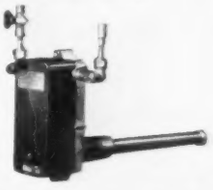
"Streamline" Modulating Valves, another exclusive Johnson development, with seamless metal diaphragms and unique throttling characteristics.

Johnson "Piston" Damper Motors, affording long-travel at full power, a feature not found in other damper motors. Available with or without pilot mechanism.

JOHNSON
PRECISE SYNCHRONIZING

Every device pictured here brings you a new conception of precision, greater flexibility, and increased understanding of what you may expect from Johnson's modern automatic control equipment . . . The Johnson line of pilot operated apparatus, for truly modulated operation by Johnson gradual acting instruments, with adjustable sensitivity, is the very latest "word" in precise synchronizing of control devices. Ask to see a Johnson engineer from a nearby branch office or send for detailed bulletins. Johnson Service Company: Milwaukee, Wis., and direct branches in all principal cities.

"Absolute-positioning" Modulating Valves, with Johnson pilot mechanism and "Streamline" gradual control characteristics. Maximum power for re-positioning at slightest command of controlling instrument.

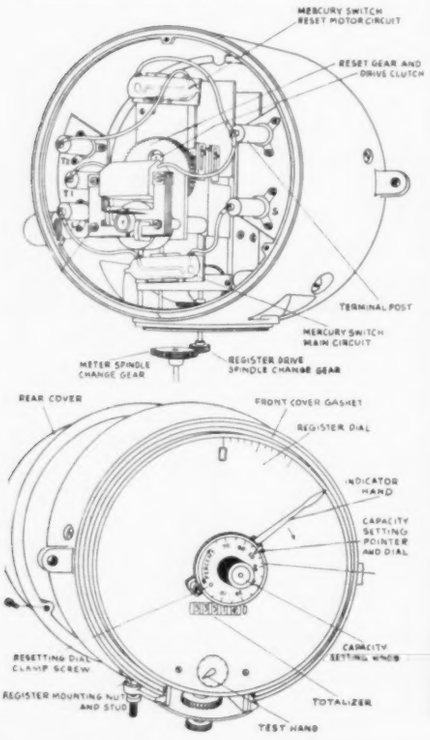


Insertion and Immersion Thermostats with Johnson's distinctive sensitivity adjustment, calibrated on the job to balance "time-lag" against the capacity of the controlled apparatus.

JOHNSON
Automatic TEMPERATURE AND AIR CONDITIONING Control

Automatic Liquid-metering Recycling Controller

New type of recycling control, known as "Design 2B Register," is for attachment on positive liquid meters used for the initiation of automatic processes. Automatic mechanism



is so constructed that when a predetermined quantity of water has passed through the meter, a contact will be made which will initiate the automatic cycle. After this, meter control resets itself and is automatically ready to measure the predetermined quantity of water before the next automatic cycle is started. Illustrations show general construction but note that entire glass-cover assembly is omitted from upper one. Features of new mechanism are that mercury switches are used throughout to provide good electrical contact and freedom from dust and corrosion problems. There are no electrical current-carrying parts on the dial. Adjustment of the quantity of water that will pass through the meter between automatic cycles is accomplished by means of an easily accessible dial visible through the glass face as are the totalizer, test hand and register dial.—*The Permutit Co., 330 W. 42nd St., New York City.*

Plug-in Filters

New Model "LF-2" is described as a special multiple section and inductance and capacity filter for use on troublesome sources of radio interference. Designed for installation at power outlet to which interfering device is connected, it facilitates selecting proper filter for any electrical device drawing up to ½ ampere. Supplied in a rounded corner rectangular case 2½" x 1¾" x 1 7-16", the filter is designed for use on 115-volt a-c. or d-c. lines only. A ground connection is provided and should be used for maximum effectiveness. For convenience, this ground may be made to chassis or frame of offending device.—*Sprague Products Co., North Adams, Mass.*

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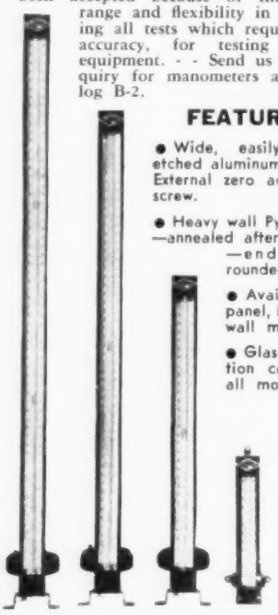
Trimount Well Type Manometers have been accepted because of their wide range and flexibility in performing all tests which require great accuracy, for testing aircraft equipment. - - Send us your inquiry for manometers and catalog B-2.

FEATURES

- Wide, easily visible etched aluminum scales—External zero adjustment screw.
- Heavy wall Pyrex tubes—annealed after forming—ends flame rounded.
- Available for panel, bench or wall mounting.
- Glass protection covers on all models.



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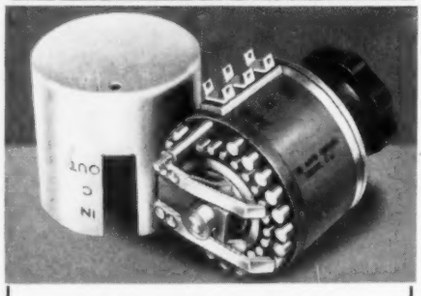
TRIMOUNT MANOMETERS

DAVEN ATTENUATORS



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The DAVEN catalog lists the most complete line of precision attenuators in the world; Ladder, "T" type, "Balanced H" and Potentiometer networks—both variable and fixed types—employed extensively in control positions of high quality program distribution system and as laboratory standards of attenuation. Super DAVOHM resistors are precision type, wire-wound units of from 1% to 0.1% accuracy. More than 80 models of Laboratory Test Equipment are listed.

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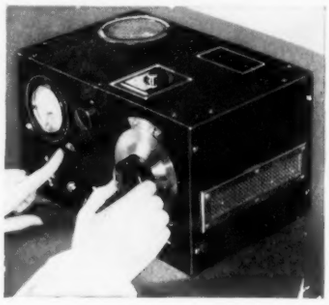
THE DAVEN COMPANY
158 SUMMIT STREET • NEWARK, N. J.

Photometer for Vitamin A

New Bills and Wallenmeyer Electronic Photometer is designed for determining Vitamin A concentration. Its operating principle is measurement of ultraviolet light absorbed by a Vitamin A solution, utilizing phototube and electronic amplification. With U.S.P. Reference Cod-Liver Oil used for calibration, vitamin units in a sample are read directly from a chart without computation. Useful measuring range is said to cover the widest variations encountered in any one species of commercial fish oil. Time required for a reading is about 90 seconds. Instrument is portable, operates from any 110-volt 60-cycle socket. Light source is an argon glow lamp having strong emission bands at about 318 and 338 millimicrons,



which are within Vitamin A absorption band and close to its maximum. These lines are isolated from the rest of the argon spectrum by means of a filter especially developed for absorbing all other light to which the phototube is sensitive. Circuit is fully compensated for changes of light intensity caused by line voltage variations. Two-stage amplifier provides required sensitivity. A logarithmic aperture serves for balancing the circuit, gives a linear calibration curve, is operated by a knob connected to a dial graduated in 100 equal divisions. Readings are reproducible within 0.5% over most of useful range. Photometer can be used also without changes or special equipment, for estimating Vitamin B_1 (by the Melnick and Field adaptation of the Prebluda-McCollum color reaction).—*Photovolt Corp., 10 E. 40th St., New York City.*

Ignitron Tubes for Welder Control

Ignitron tubes for resistance welder control now have both inner and outer jackets of stainless steel and are completely corrosion resistant. New tubes, particularly

adapted to this service, can carry high peak currents for short periods, are available in ratings suitable for controlling nearly all sizes of resistance welding machines.—*General Electric Co., Schenectady, N. Y.*

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Every thermocouple user needs a copy of this new Wheelco Bulletin. It not only contains prices and descriptions of our complete line of thermocouples and thermocouple accessories but, in addition, gives recommendations for their selection and use. Essential data—the making of thermocouples, temperature conversion and millivoltage tables, wire resistances, etc.—are also included.

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Wheelco Instruments Co.

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IMPROVED "SPOTLIGHTS"

Rubicon MULTIPLE REFLECTION galvanometers have recently been much improved through redesign of optical system. The definition of the line-image is now so sharp that readings can be estimated to .1 of a millimeter division.

These sturdy self-contained galvanometers are available with sensitivities as high as 5×10^{-10} ampere and 1×10^{-6} volt per millimeter division.

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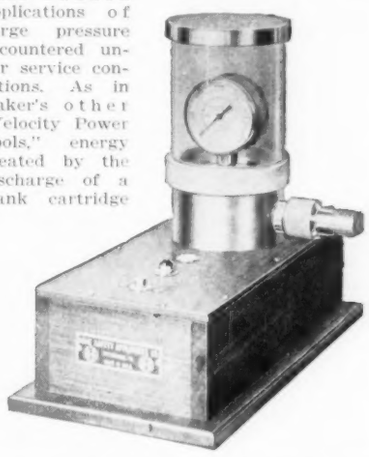
Galvanometers, Electrometers, Potentiometers, Colorimeters, Wheatstone & Kelvin Bridges, Resistance Standards, Resistance Boxes, Coil Testers, Clip-on Ammeters, etc.

Molding Sand Sampler

New Molding Sand Sampler has length of handle such as to allow samples to be taken 24" from outer surface of heap. Sand pushes through tapered container as sampler is pushed in. Thus the sample is representative. When operator pulls sampler from sand, tapered container grips the 700-gram sample. — *Harry W. Dietert Co., 9330 Roselawn Ave., Detroit, Mich.*

Impulse-method Tester for Pressure Gages

New "M.S.A. Velocity Power Gage Tester" is designed for safely testing gages used in conjunction with compressed gas storage cylinders, to determine their ability to withstand sudden applications of surge pressure encountered under service conditions. As in maker's other "Velocity Power Tools," energy created by the discharge of a blank cartridge



is utilized as a source of pressure. Severe impulse load gives assurance of gage's ability to perform satisfactorily in service, it is stated. A transparent guard, covering gage to be tested, permits visual observation at all times. Pressures resulting from cartridge discharge are transmitted directly to gage, causing it to function in a normal manner under high initial loads. A signal light indicates that gage has been subjected to required test pressure.—*Mine Safety Appliances Co., Braddock, Thomas and Meade Sts., Pittsburgh, Pa.*

Midget Indicator

New "Universal Midget Indicator" differs principally from conventional small-size indicators in that it contains a completely geared and fully-jeweled transmission, without cam or lever action. Measuring spindle moves in a straight line, not in a circular arc. Indicator is made to measure to 0.0001". Dial graduations are $\frac{1}{8}$" wide. Graduation in 0.001" and 0.01 mm. or 0.005 mm. is also available. Length, $2\frac{5}{8}$"; width, $1\frac{1}{8}$"; dial diam., 1"; weight, 2 oz. Optional accessories such as bellcrank lever, universal joint holder, and round and flat faces are available.—*Standard Gage Co., Poughkeepsie, N. Y.*

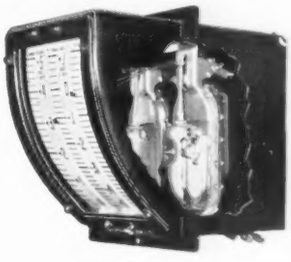
BAILEY METERS

METERS and CONTROL *for Boiler Room Service . . .*

Boiler Meters Reduce fuel costs, lessen maintenance and outage, lower standby costs, and add capacity. They indicate, record and integrate Steam Flow from the boiler, record Air Flow supplied for combustion and record Flue Gas Temperature.

Bailey Boiler Meter

Multi-Pointer Gages for indicating drafts, pressures, differentials are available with any number of pointers from one to twelve. They are actuated by sturdy yet sensitive diaphragm units.



Multi-Pointer Gage

Flow Meters. For indicating, recording and integrating the flow of steam, feed water, compressed air and other fluids.

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Granular Material Meters For accurately measuring the flow of coal or other granular materials in gravity chutes from overhead bunkers. The total quantity of granular material is shown on a large illuminated counter which may be easily read at a distance of 50 feet.

Control Systems Make possible the everyday operation of equipment for steam generation and utilization at test efficiencies. They are applied to the control of combustion, feed water, superheat, desuperheat and other factors.

Complete Information on any of the above Bailey products will be gladly furnished upon request.

G-14

BAILEY METER • COMPANY •

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BAILEY METER COMPANY LTD., MONTREAL

Millisecond Timer

In measuring time intervals of the order of a few milliseconds, errors due to starting and stopping the measuring apparatus (inertia and friction of moving parts, etc.) preclude the use of electromagnetic devices. In the development of a new millisecond timer, known as the "Remington Arms Company Chronoscope," a new application of ballistic-galvanometer principle is said to have so eliminated possible sources of error that accuracy of within 1% can

be obtained in measurement of time intervals of 1 to 200 milliseconds, covered by five ranges: 0-10-20-50-100-200. During the interval of time to be measured, a known current is passed through a ballistic galvanometer, this current being switched on and off by means of two Thyratrons. A positive pulse is applied to grid of first tube, igniting it and thereby passing previously-calibrated current into ballistic galvanometer circuit. At end of interval, a pulse is applied to second tube which is so connected as to lower potential of plate of first tube to below its extinction point, cutting off current through galvanometer. Throw of pointer is proportional to quantity of current passed and therefore to measured time interval. Exact relation is $T = D/K\,I$, where D is number of divisions deflection obtained, K is galvanometer constant expressed in divisions of scale deflection per microcoulomb, I is current in milliamperes, and T is time interval in milliseconds. To prevent damage to galvanometer in event of failure of generation of the second pulse (applied current being many times greater than that required to give full-scale deflection for continuous currents) an automatic pulse generator is built-in to provide a second pulse before enough charge has passed through circuit to damage galvanometer, in case a second pulse is not supplied by external circuit. Calibration of the known current is accomplished by a switch on front panel, which removes galvanometer from circuit while current is adjusted by a series rheostat and read on a milliammeter included in instrument. A check on galvanometer calibration is provided by discharging a standard capacitor charged to a measured potential by the internal batteries. Dimensions: 19"×12"×11". Weight, 44 lbs.—*Rawson Electrical Instrument Co., Cambridge, Mass.*

Extra-heavy-duty Plug-in Tube-type Resistors

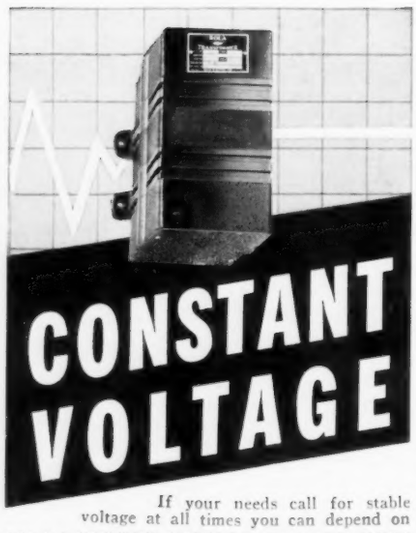
New glass-insulated-element plug-in tube-type resistor, "Type MTG," is for extra-heavy-duty service. Instead of usual bare helical wire winding supported directly on mica "card" or form, new type employs a fibre-glass core for the winding which may also be covered with a fibre-glass braiding, supported on the mica. Glass-insulated element handles over three times wattage of usual bare winding. Some units are made with a combination of bare winding and glass-insulated winding, supported on the same mica form.—*Clarostat Mfg. Co., Inc., 285-7 N. 6th St., Brooklyn, N. Y.*

Fluorescence Meter for Vitamins B_1 and B_2

New "Lumetron Fluorescence Meter" is a photoelectric instrument for measuring the fluorescence of a solution as required, for instance, in thiochrome method of determining Vitamin B_1 and in method of D. B. Hand for determining Vitamin B_2. It is claimed as a feature of instrument's design that instability of readings, caused by fluctuations of the light output of the mercury-vapor lamp, are effectively eliminated and that strictly reproducible measurements are obtained. Such stability is not attainable by merely holding mercury-lamp voltage constant because mercury light reacts also to thermal influences. In new instrument, stable readings are obtained by use of a balanced bridge circuit: Light of a mercury vapor lamp, after passing through a filter which transmits only ultraviolet radiation, is split into two beams, one entering sample holder and acting by fluorescence on the measuring photocells, the other acting upon a balance photocell. Ratio of currents is used to measure fluorescence so that a change in the light output, acting equally on both measuring and balance cells, has no effect upon the readings. About 12 cc. of liquid are sufficient for fluorescence determination. Color filters between sample holder and photocells eliminate influence of primary (ultraviolet) radiation which may be scattered by suspended particles in solution, thus excluding effect of turbidity. Null detector is a multiple-reflection galvanometer (G-E Co., see *Instruments*, Feb. 1941, page 36). Readings are taken directly on the dial of a slide wire of linear characteristics. To avoid non-linearity of readings, caused by logarithmic response of photocells if working against a load resistance, cells are connected in a "zero potential circuit" in which the measuring cells operate against zero resistance when galvanometer indicates balance. Mercury vapor lamp has an all-quartz envelope and highly concentrated mercury arc, is of high-pressure type having strong emission in the particular ultraviolet region which causes fluorescence. Optical system also is of pure fused quartz.

Same instrument can be used for transmission measurements: for instance, to determine Vitamin A concentration. Moreover, mercury vapor lamp can be replaced by an incandescent lamp for determination, by means of transmission in the visible range, of Vitamins C, D, E, carotene and nicotinic acid as well as to general colorimetry and abridged spectrophotometry.

For taking reflection measurements on solids, powders and opaque liquids, a reflection search unit can be connected to the instrument. This unit comprises a photocell and an incandescent lamp as well as a lens which forms a light spot of about 1" diam. on surface under test. Bulb of search unit operates in parallel with bulb inside instrument so that stability of readings is maintained. Search unit permits the use of color filters for trichromatic and abridged spectrophotometric analysis. — *Photovolt Corp., 10 East 40th St., New York City.*



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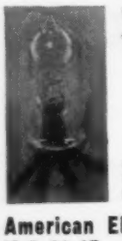

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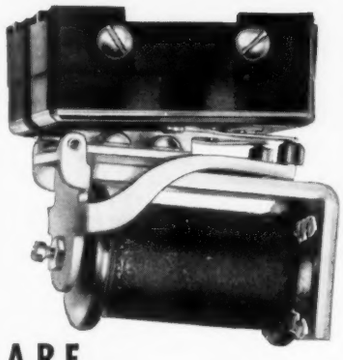

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RELAY

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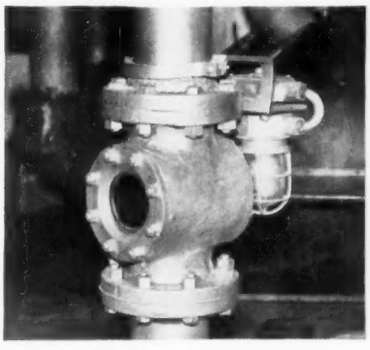
Voltage Regulator

"Steadi-Volt" is a new type of voltage regulator for laboratory apparatus, production testing and heating equipment, electronic instruments, etc. Input voltage may

vary from 95 to 130 volts; output voltage is maintained within 1%. It is said that there is a negligible variation in output voltage from no load to full load, permitting use of device at any rating up to maximum. A triple-output receptacle provides 110, 115, or 120 volts. Efficiency and power factor are said to be "high" and distortion "relatively low for a unit of this type." New operating principle involves no moving parts, assures instantaneous response. — *United Transformer Corp., 150 Varick St., New York City.*

Flow Indicators

The six "Sight Glass" flow indicators previously announced (*Instruments*, Jan. 1940, page 28) have been supplemented by five smaller sizes with screwed connections.



Sizes range from ¾" to 2" for new screwed connection fittings and from 2½" to 8" for flanged design. Bodies are of cast iron for pressures to 125 lbs/in.². Pyrex windows are held in place by gasketed steel frames. Weights have been reduced on all sizes.— *Cochrane Corp., 17th St. & Allegheny Ave., Philadelphia, Pa.*

Drafting Machine

New "Master-Drafto Model No. 60" takes a maximum size sheet 24" × 36". Its arms are constructed of seamless steel tubing, fitted with solid bearings. Scale blades are so designed that any scale, either boxwood or aluminum, can be inserted; and it is said that these scales will fit tightly into the blades without deviating from the necessary 90° angle. For center mounting the machine on a drafting board or table, a cast aluminum bracket is used, containing a screw for leveling the scales parallel to the drafting surface. Stainless steel protractor plate is graduated in 2° and can be set for ½° readings by use of the graduated vernier. Graduations are machine cut. Protractor can be locked at any degree, but for speed and convenience is fitted with a latching spring to lock the scales at 0, 30, 45, 60 and 90° on either side of the 0° reading. —*The Drafto Company, 175 Walnut St., Cochranton, Pa.*

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Easy to operate, requires no technical knowledge.

Tests and compares the resistance of coils, resistors from a fraction of an ohm to 10 megohms or more.

Built-in adjustable Resistance Standard. Built-in suspension galvanometer.

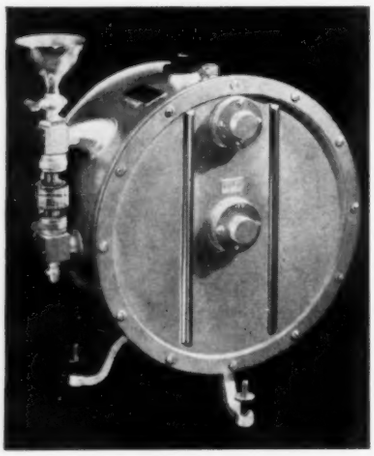
±2 — 5 — 10 — 15 — 20%
or any other combination

Write for Bulletin No. 146-HT

SHALLCROSS MFG. CO.
Instruments – Resistors – Switches
COLLINGDALE, PA.

Wet Test Meters

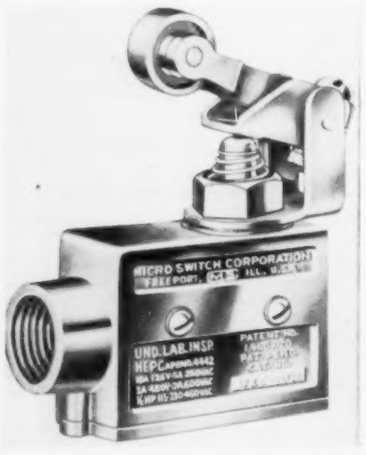
A removable back head is announced for maker's line of wet test meters, in order to facilitate cleaning and access to drum. When specified, any of "American A1-18" series of wet test meters for general laboratory testing and for calorimetry (including



both the low-pressure and the new high-pressure models) now may be equipped with this device. Its use is said to be especially convenient where gas conditions make periodical washings advisable. First-hand inspection also is simplified, so that corrosion and other effects may be observed more readily, and need for repairs lessened. Improved back head assembly may be attached not only to new models but also to meters (with either flat or convex back heads) already in service.—*American Meter Co., 60 East 42nd St., New York City.*

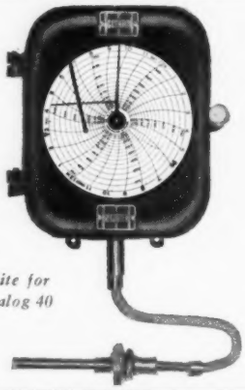
Roller-arm "Micro Switch"

New metal-clad "Micro Switch" has a roller arm adjustable vertically through an arc of 225° around its pivot pin, and also horizontally in eight positions 45° apart. It is suitable for slide or cam actuation. A ¾" diam. roller of hardened and ground steel is carried on an oilless bronze bearing. Arm is aluminum die-casting. (Metal-clad switch



unit was described in *Instruments*, August 1940, page 202.) Inner Micro Switch element is rated by Underwriters' at 1200 watts up to 600 volts a.c. It is single-pole only, with normally-closed, normally-open, or double-throw contact arrangements. New switch operates on 2° to 4° movement with provision for 20° to 30° overtravel of arm. Standard ½" conduit hub with wire way for two No. 10, or three No. 14, weather-proof wires, is provided. Wiring is to screw terminals.—*Micro Switch Corp., Freeport, Ill.*

Temperature Instruments



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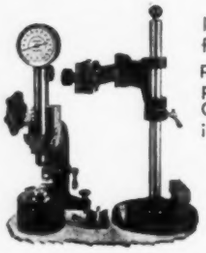

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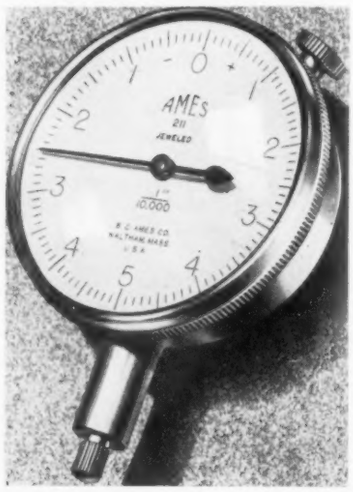
Dial Indicators

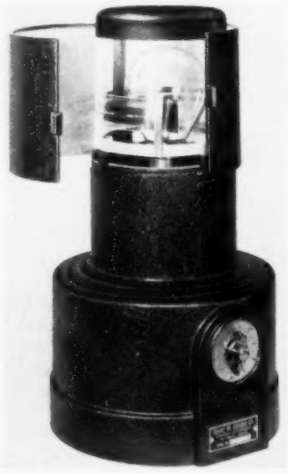
"Hundred Series" dial indicators are announced as "entirely new." However, they retain numerous refined features of design and construction developed by makers and



previously described (*Instruments*, Sept. 1936, page 243; May 1938, page 136; April 1939, page 106). Makers' announcement lays stress on compliance in every respect with gage characteristics and dimensions adopted by American Gage Design Committee. Hands start at 9 o'clock position, make 2½ turns around dial and stop at 3 o'clock position. Range of each indicator is thereby determined by number of dial graduations. New indicators are available in four sizes: 1⅛", 2¼", 2¾" and 3⅝", with choice of fourteen different dial numberings.—*B. C. Ames Co., Waltham, Mass.*

Spectrochemical Analysis Film Dryer

"Infra Red-Film Dryer," added to maker's line of spectrographic analysis equipment, will dry a 16" length of 35-mm. film in 50 seconds without curling it. Wet film



is stretched around a glass form. An infra-red lamp is located within this form and a motor-driven fan in base of dryer forces warm air around outside of glass form, so that film is dried by infrared radiation and by current of warm air. Air used is filtered. An electric timer starts and then stops blower and cuts off current to infra-red lamp after a predetermined time.—*Harry W. Dietert Co., 9330 Roselawn Ave., Detroit, Mich.*

Magnetometer

New magnetometer is designed for the routine testing of permanent magnets, but may be adapted for testing coils. Usual size is 7¾" × 5½" × 4½". Scale is 3¾" long. Contacts for the magnet being tested are two iron bars ¾"×¾", extending ⅛" from end of case, 1¾" apart center-to-center. Both bars have tapped holes at the center so that pole-pieces may be attached for smaller, larger, and odd-shaped magnets. Special extensions are made to fit particular needs of user. Dials normally have an arbitrary scale marked from zero to one hundred, but special scales can be furnished to suit. While originally designed for permanent magnets, *coils* may be tested by passing the coil over a piece of soft iron which fits the pole extensions. By passing a known current through a standard coil, similar coils may be compared. New instrument operates on one flashlight cell.—*John C. Bank, Wayne, N. J.*

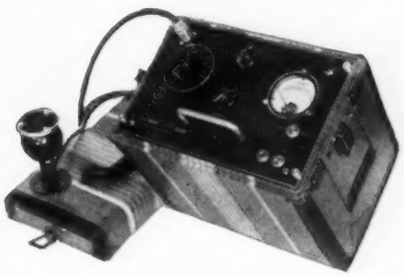
Photoelectric System for Flame-failure Safety

For protection in event of failure of luminous flames (oil, powdered coal, raw gas, etc.) new "Protectoglo Photo-electrode System" employs photoelectric detection, there-

by obviating need of locating a metallic electrode in flames and therefore finding preferred application where flame temperatures are too high for metal electrodes. In function and operation it is similar to maker's "Flame-electrode Protectoglo" (*Instruments*, Jan. 1932, page 20; May 1936, page 123) but differs therefrom in that it employs a photocell located not within the flame but at a distance. Cell output is amplified, by a vacuum-tube circuit, sufficiently to actuate a relay. Response of system to flames of different luminosity may be adjusted. With adjustment in maximum position, unit will respond to the light of a candle; at other extreme, no amount of light will close relay. To prevent transient flame disturbances from causing unnecessary shut-downs, a time lag in relay operation is provided by the discharge of a small capacitor at the right of the sensitivity adjustment. Lag is a function of flame luminosity and of sensitivity adjustment. For a given sensitivity setting, lag will increase with an increase in luminosity of flame. Similarly, for constant luminosity, increasing sensitivity will increase time lag. Under conditions described, this lag can be varied from zero to a maximum of 10 seconds. A door switch connected in series with relay coil de-energizes relay whenever door is opened. Unit is supplied with a swivel mounting which can be screwed to a length of 1¼" pipe supported from floor. This isolates unit from heat of burner and furnace wall and provides a ready means for sighting on flame. System is supplied for 115 volts, 25 to 60 cycles. Furnished as a cut-off model, for manual re-starting. *The Brown Instrument Co., 4482 Wayne Ave., Philadelphia, Pa.*

ANNOUNCING

NEW RA-330 SOUND LEVEL METER



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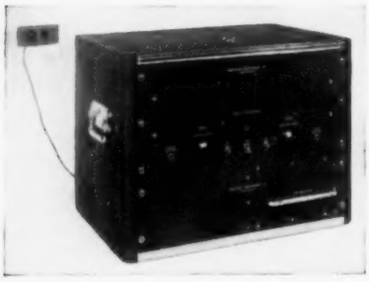
Tuning-fork-controlled Time Standard

A shielded self-starting electrically-driven tuning-fork, free of all mechanical restraint, is the primary time source in new "No. 5-3500 Time Standard." Regular model of



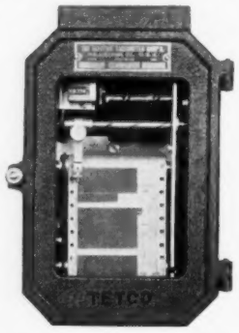
fork has a frequency of 500±0.1 cycles at 25°C. (closer tolerances special) and a temperature coefficient of —0.06 cycle/deg.C. Thermometer regularly provided can be read to 0.1°C. (Model "No. 5-3502" is provided with a constant-temperature box for tuning-fork.) Instrument comprises, beside tuning-fork, an electrically isolated pickup and power amplified; and hence may be described as a self-contained stable fixed-frequency power oscillator. Output is undistorted sine-wave, steplessly controlled from 0 to 2.5 watts by a knob on panel, 25-volt max. undistorted voltage at 500 ohms. Output impedances of 4, 8, 15 and 500 ohms are available at the turn of a switch. All output connections shielded. Two jacks on panel for testing fork-driving amplifier and output amplifier. Instrument operates on 115-volt 50-60-cycle single-phase a.c., consumes 200 watts. Dimensions 21" × 13½" × 15¾". Weight 74 lbs.—*American Instrument Co., 8010 Georgia Ave., Silver Spring, Md.*

Motorized Valve

New "Motor-operated Saunders' Patent Valve" is said to be particularly adapted to the automatic control of corrosive fluids, liquids containing solids, viscous and volatile substances or gases. It may be used to control liquid level in tanks, vats, etc.; density of solutions in evaporators; flow of reagents in pH control, treatment of water, sewage, boiler feed water, etc. Valve bodies are available in various types of alloys, or cast iron lined with lead, rubber, or glass to meet requirements of particular service. Diaphragms resistant to the fluids handled are available. Construction eliminates stem packing or stuffing box and is said to prevent corrosion, clogging or sticking of working parts. Once installed, body remains in line, as only service necessary is occasional replacement of diaphragm, which does not require removal of valve from line. Heavy-duty motor-operator may be controlled directly from a liquid level, float, or pressure switch, relay, thermostat, pH controller, push button, etc. Auxiliary switches are provided for operating other equipment such as indicating lights, relays, starters, etc.—*Barber-Colman Co., Rockford, Ill.*

TETCO

Speed Recorder



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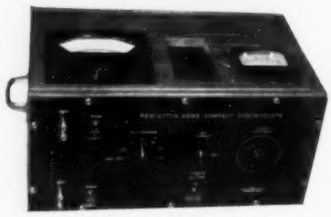

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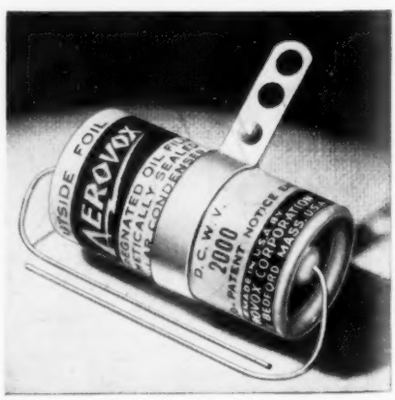
Dial Snap Gage

Ordinary snap gages set to fixed limits are suitable where varying pressure is immaterial. However, if close tolerances have to be maintained, to the order of 0.0001",

more refined gaging means are required. New Standard Dial Snap Gage is so designed that the pressure applied is constant and measurements are invariably repeated. Newly-designed indicator, graduated in 0.0001" or 0.001", 0.01 mm. or 0.005 mm., is built into frame of gage. Dial is convenient to read while gage is in operation, as it is in direct line of vision above operator's hand. Internal mechanism is shockproof. Gaging faces are tipped with tungsten carbide, beveled on the front edge. Zero setting of gage is effected with gage blocks or cylindrical masters, and locked by the AGD standard lock for snap gages. Each gage has $\frac{3}{16}$" range. Eight sizes cover all dimensions up to 4$\frac{1}{16}$", ranges overlap $\frac{1}{16}$". Change from one size to another is said to take only a few seconds. Total height of gage is 3$\frac{7}{8}$".—*Standard Gage Co., Poughkeepsie, N. Y.*

Oil-filled Capacitors

Oil-impregnated oil-filled capacitors in tubular form for amplifiers, in test instruments and laboratory rigs, are announced as a standard item. New "-89" Series has



a cadmium-plated brass can for thorough hermetic sealing, covered by a varnished-paper jacket with spun-over ends to prevent shorting or grounding of sharply-bent leads. Available in 400 v., 600 v., 1000 v. and 200 v. ratings, 0.006 to 0.5 mfd. capacities.—*Aerovox Corp., New Bedford, Mass.*

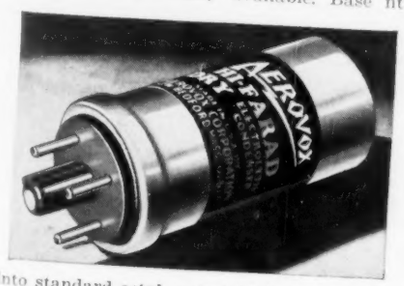
Wire Insulation Tester

With a new portable device for testing the physical toughness of magnet wire insulating film, the insulation of the wire can be subjected to a repeated scrape abrasion

test utilizing a needle which acts as a mechanical "finger-nail" to wear through the wire insulation to the metal underneath. Contact of needle and wire closes an electric circuit and the device stops automatically, thus making the test independent of the operator's judgment. It is said that in previous tests of this character the wire was either pulled under a scrape edge or attacked by an abrasion drum. It is claimed that in the latter case it was difficult to maintain a constant abrading surface; and that the former gave inconsistent results with the new tough films due to alternate gouging and skipping. New repeated scrape abrasion test is said to combine the major advantages of both. The side of a needle (ordinary sewing type) is used. Held firmly against the wire by small weights, it is driven back and forth by an eccentric mechanism connected with a counter to record the number of scrapes. An electric motor furnishes the power. Only a few inches of wire are required, and the wire can be rotated so that film toughness may be explored both along and around the wire. While designed primarily for new insulations of the "Formvar" type, the instrument may be used to study any kind of enamel or film used on wire.—*General Electric Co., Schenectady, N. Y.*

Electrolytic Capacitors

Originally made to order for military, aircraft and other users of continuous-service equipment, maker's plug-in electrolytics are now generally available. Base fits



into standard octal socket. Units are readily removable as are regular radio tubes. They are available in the 525 v. surge 450 v. D.C.W. rating, and in 10 to 80 mfd. single-section, 10-10 and 20-20 double-section, 10-10-10 triple-section, and the 10 × 10 × 450 + 20 × 25 combination. — *Aerovox Corp., New Bedford, Mass.*

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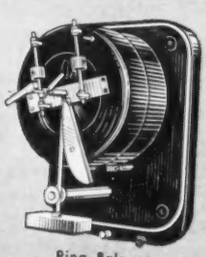

Ring Balance Meter

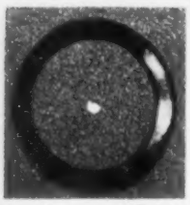
Pressure & Temp. Recorder

COCHRANE CORP., 3120 N. 17th St., Philadelphia, Pa.

COCHRANE
FLOW METERS

Surface-finish Tester

New "Research Model" is added to line of "Abrasers" (see *Instruments*, Sept. 1937, page 227; July 1939, page 172; May 1940, page 122) for evaluating resistance of surface finishes to rubbing abrasion, such as paints, lacquers, electroplated and plastic surfaces and textile fabrics ranging from sheer fabrics to upholstery. Tester comprises a motor-driven turntable on which specimen is mounted, a counter to indicate the number of abrasion cycles, and two abrading wheels that alternately rub back and forth and, at the same time, criss-cross in their rolling path. These wheels are made in five types. Standardized load adjustments permit varying pressure against specimen to suit the type of material being tested. Supplementing wear resistance test is the Shear-Hardness test performed by attachment E-3720 which measures the toughness quality of a plastic surface or its ability to resist digs, scrapes, and similar physical damage not classed as normal wear.—*The Taber Instrument Co., North Tonawanda, N. Y.*



Wrinkle enamel finish (worn smooth, then through thinnest part)

Anodized Aluminum (Hard oxidized surface worn off: soft interior)

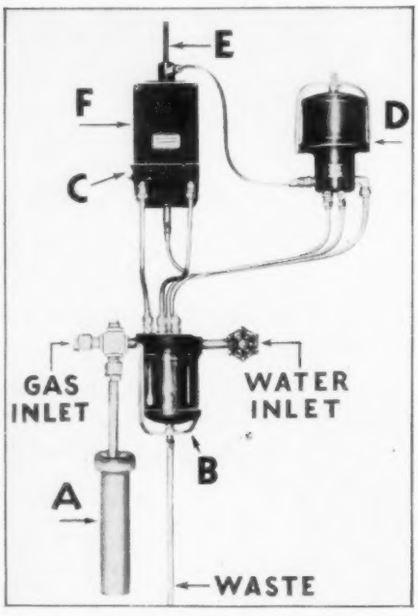
Electron Microscope

[Ed. Note. Description of first semi-commercial model did not appear in "New Instruments" Dept., was briefly given in article by Dr. Zworykin in our June 1940 issue, page 151—which, by the way, was the first in any magazine.]

Details of a more effective and simplified model of the RCA Electron Microscope have been announced. First model had a resolution of 50 Angstroms but was designed primarily for use by electrical experts and physicists. New model is better adapted for use in general medical and chemical laboratories, may be operated by any competent laboratory worker. In addition it reveals even finer detail: it magnifies objects up to 100,000 times. It is less than one-half the size of the earlier model, is ready for operation when plugged into an ordinary light socket, whereas first model required a roomful of power supply equipment for its operation. An adaptation of a radio transmitter circuit provides the high voltages required. In the new instrument there are a number of windows through which several persons can study specimens at the same time. It is not affected by magnetic fields set up by other electrical equipment, as was the earlier model, nor disturbed by ordinary room vibrations. A "submarine lock" arrangement permits changing specimens in the evacuated chamber without admitting air. Specimens may be changed within a minute. This is said to make it possible to use the electron microscope to check production processes periodically, in addition to pure research. Electron beam is directed through the specimen, through various stages of magnetic field coils, and then is made to strike a photographic plate to make an electron micrograph, or to strike a fluorescent screen so that image becomes visible.—*RCA Mfg. Co., Camden, N. J.*

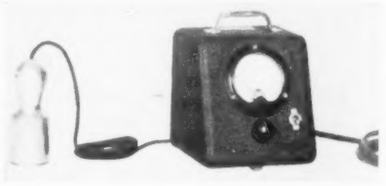
Oxygen Concentration Recorder

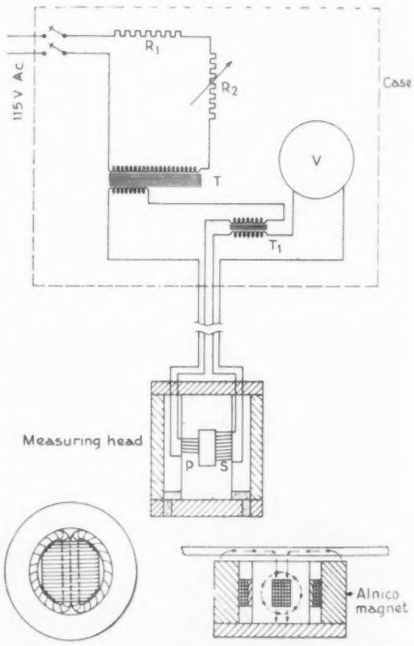
Continuous indications and autographic records of percent of oxygen in any *gas* (not in liquids) are provided by new Oxygen Recorder. Operating principle involves passing continuous sample through a furnace for removal of its oxygen. Concentration-measuring principle is based on difference between thermal conductivities of "plain" and de-oxygenized streams. Gas is drawn into analyzer by a bubbler-aspirator *B*, condensate falling into drip pot *A*. Aspirator draws about one liter per minute. Gas is thus scrubbed and metered. At elbow, incoming gas divides into two streams, one of which flows directly to aspirator and acts as a line purge. Remaining gas flows through a secondary filter and orifice *C*, thence to an inner bubbling tube in aspirator, thence to one side of analyzer *D*, through tube *E* in furnace, back through other side of analyzer and then to bubbler aspirator where it goes to waste along with main gas stream. Center tube *E* of furnace contains a carbon rod heated so that oxygen in gas is converted to CO_2. (Supply of carbon in furnace is usually sufficient for more than a week's operation; carbon is automatically fed into furnace.) Original gas containing oxygen thus passes first through reference-cell of analyzer *D* and later (minus its oxygen) through measuring cell. "Meter unit" is arranged to measure difference in thermal conductivity between the bases on the two sides, which is proportional to oxygen concentration of original gas. Result is not affected by any changes in the original CO_2 or N_2 concentration. Standard range is 0 to 5% on a 10" scale, but instrument can be scaled in ranges of 0 to 2% oxygen full-scale and 0 to 100% oxygen full-scale. Various analyzing cells may be combined so that instrument will provide "a complete gas analysis on one chart," it is announced. Equipment operates from electric supply line, is designed and constructed for severe service in industrial plants as well as in laboratories. —*Cambridge Instrument Co., Grand Central Terminal, New York City.*



Sheet-steel Thickness Gage

A new magnetic gage which "for the first time measures the thickness of sheet steel when only one side is accessible" is accurate to 0.001". It consists of a 7-lb. portable indicating unit (operating from an electric outlet) and a cylindrical head containing an Alnico magnet. When gage head is placed against material to be measured, permanent magnetic field of head saturates material. Thickness of material determines flux passing through gage-head magnetic circuit, hence increased reluctance of magnetic circuit and consequent deflection of instrument—whose scale, however, gives direct readings in mils. Thickness of any magnetic sheet or plate material may be measured by this gage as long as material is not backed by other magnetic material. Gage is especially valuable for checking center and other points on wide sheets where use of calipers is inconvenient or impossible. It permits quick determination of uniformity of material, measurements from one side only, reduction in cost of material from over-thickness and more uniform sheets with resulting reduction in fabrication costs. Initial instrument made in the laboratory has two scales: 20 to 45 mils for low carbon steels, 10 to 25 mils for electrical sheet steels of medium silicon content. Gages can be made to measure thicknesses up to 250 mils (¼") with the same relative accuracy and even thicker if portability is sacrificed. Larger thicknesses would require larger gage heads to supply the magnetic saturation. — *General Electric Co., Schenectady, N. Y.*





Elimination of the Viscosity Error in Flow Measurement with Rotameters*

By KERMIT FISCHER, SEYMOUR BLECHMAN and EUGENE LIPSTEIN

Fischer & Porter Company, Philadelphia, Pa.

A SHORTCOMING of the rotameter has been the great variation of the calibration with variation in viscosity of the fluid handled. While this calibration sensitivity tended to decrease as the size of the rotameters increased, nevertheless it was still great enough in 3" and 4" rotameters to cause considerable inconvenience. In small rotameters (¾" diameter) the effect of viscosity changes on calibrations was so great that flow rate prediction, even by the Schoenborn-Colburn equation[1], became almost impossible, and was a rough approximation at best.

In Fig. 1 are plotted the results of calibration tests of a ¾" rotameter as built before the investigations herein reported were made. The tests were run with water, oil at 120°F., and oil at 90°F., with viscosities, respectively of 1, 19.9 and 44 centistokes. The ordinates show the height of the float in the metering tube, the abscissa the flow rate in g.p.m. The distances between the three curves are chiefly a measure of the effect of viscosity change. So great are these distances that accurate interpolation between them seems out of the question.

Plotting the figures another way, as flow coefficient C versus Reynolds number Re, divided by C, yields the results shown in Fig. 2. In the Schoenburn-Colburn equation

$$Q = CA\sqrt{\frac{2gV_f(\rho_f - \rho_w)}{S_f\rho_w}}$$

the flow coefficient C is, as in the orifice meter, mainly influenced by the fluid viscosity. The Reynolds number $Re = \rho vD/\mu$, is the commonly-accepted parameter to represent flow similarity.[2] C as the ordinate is plotted against Re/C as the abscissa instead of against Re only in order that flow rate will not appear in both ordinates and abscissa. It will be seen that the points are badly scattered and that the best line that can be drawn through them is neither straight nor horizontal. Obviously, if the curvature could be eliminated and the line be given a uniform slope, prediction of rotameter calibration would be considerably simplified.

NOTATION

Q = Volumetric flow rate
C = Flow coefficient
A = Cross-sectional area of flow annulus at any specified height (tube area – area of float at largest diameter)
g = Acceleration of gravity
V_f = Volume of float
S_f = Cross-sectional area of float at largest diameter
ρ_f = Density of float
ρ_w = Density of fluid
Re = Reynolds number
v = Velocity through flow annulus
D = Equivalent diameter of flow annulus (inside diameter of tube at any specified height – diameter of float at largest portion)
μ = Absolute viscosity

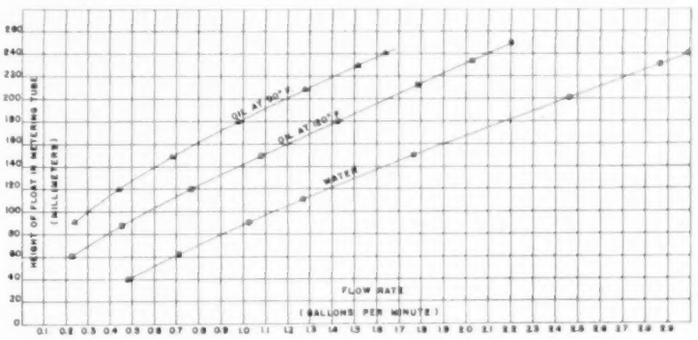


Fig. 1. Calibration curves for Size 5 Rotameter with "old style" float tested with oil and water.

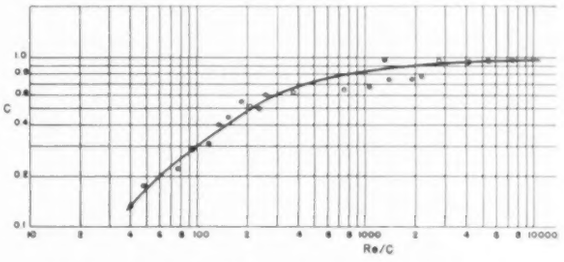


Fig. 2. Rotameter coefficients vs. Reynolds Numbers for "old style" floats.

UNTIL around 1938, only one American technical magazine (this one) recognized the existence of a "float type" in the "area class" of flowmeters and gave this type an amount of space befitting its industrial importance. Our article in the December 1932 *Instruments* remained for years the only adequate treatment of this type in English. Nonrecognition by others may have been due, of course, to the scarcity of readily-usable data obtainable only by imaginatively-varied research. No society was both willing and able to finance such research. The Fischer & Porter Co. has conducted such research. One result: discovery of a new method of minimizing errors. Because this article reports the research and describes the method, we have accepted it for publication in spite of the fact that it incidentally describes a new commercial product—a description which otherwise would be printed briefly in the "New Instruments" Department.—M. F. BEHAR, *Editor*.

*Substance of a paper presented before the Am. Inst. of Chem. Engrs., Dec. 1940, New Orleans meeting.

[1]See "The Flow Mechanism and Performance of the Rotameter" by E. M. Schoenborn, Jr. and A. P. Colburn, *Transactions Am. Institute of Chemical Engineers*, Vol. 35, No. 3, June 25, 1939, pages 359-389. In this paper, Schoenborn and Colburn developed for the first time an adequate equation to interpret the action of the rotameter. They showed how this equation could be utilized to predict capacities and approximate calibrations for rotameters handling fluids with which they had not been calibrated from available calibration data for the same rotameters with other fluids. They made clear the similarity, from a theoretical standpoint, between the rotameter and the well-known orifice meter. Their work not only made available a new method for solving rotameter problems but also brought out the viscosity effect more clearly than ever before.

[2]R. W. Keith. How the Reynolds Number Originated and How to Compute its Value. *Instruments*, Vol. 8, Aug. 1935, pages 198-200, 205. (Lists twenty-two references.)

Also: Ed S. Smith, Jr. Alternative Forms of the Reynolds Number. *Instruments*, Vol. 8, Aug. 1935, page 201.

Also: J. L. Hodgson. The Reynolds Number. *Instruments*, Vol. 8, Dec. 1935, page 322. (Clarifies origin and application.)

If, furthermore, the line could be made horizontal, representing a constant-value coefficient C, then a single capacity determination for a rotameter with any fluid and with the float held at any position in the metering tube would determine the value of C for that particular rotameter and would permit calculation of capacity for any other fluid and any float position by the Schoenborn-Colburn equation.

Experimental Work

As previous attempts to improve the operation of rotameters by using spheres, spheroids, and streamlined shapes had proved futile, the investigation was begun by a study of the flow around immersed bodies and the viscous drag on such bodies. A plot of drag coefficients as functions of Reynolds numbers for spheres and disks (Fig. 3) gave interesting clues. It will be seen that with Re less than unity, the plotted points for both spheres and disks fall on a straight line coincident with the line obtained by calculation using the Stokes equation for freely-falling spheres. However, at Reynolds numbers greater than 1, the plots for both disks and spheres show gradually decreasing slopes. When Re is approximately 1,000 the curve for spheres tends to flatten out at a drag coefficient value of 0.4; but when 10,000 is reached, the slope of the curve is found to be reversed so that drag coefficient is increasing with Reynolds number. At 20,000 the curve again reverses its direction and abruptly drops to a value of approximately 0.17. Thence it again rises slightly, to level out at a value of 0.2. The reason for the abrupt drop lies in a change in the conformation of eddies in the wake behind the sphere and can be easily understood from an inspection of photographs of these eddies.

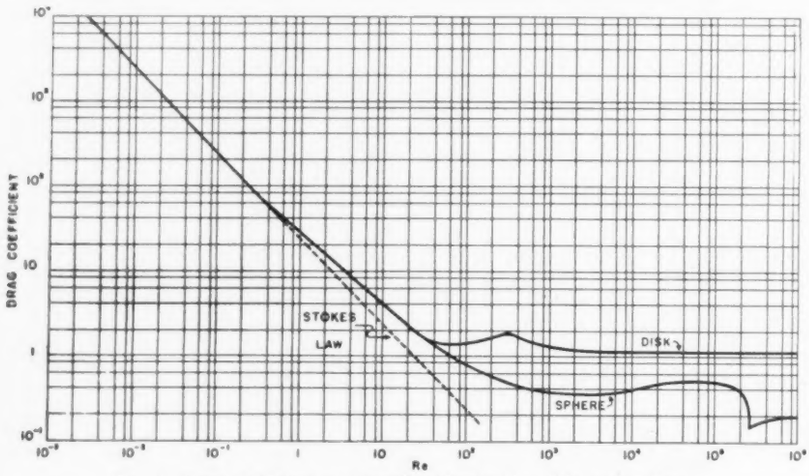


Fig. 3. Drag coefficient vs. Reynolds Number for disks and spheres.

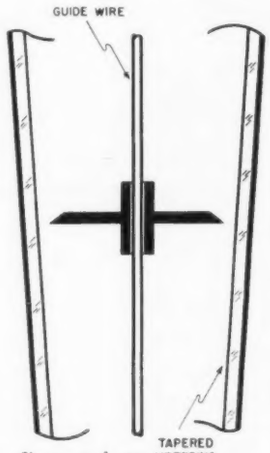


Fig. 4. Shape and arrangement of first experimental float.

Since the flow coefficient could be expected to vary inversely as the drag coefficient, it seemed clear that spheres or spheroid shapes offered little hope of improvement for the rotameter. On the other hand, the curve for disks does not contain any sharp break similar to the break at $Re = 20{,}000$ for the spheres and, furthermore, the horizontal tendency of the curve becomes quite noticeable at a Reynolds number as low as 80. Above 2,000 the curve becomes a straight, horizontal line. It seemed that if a rotameter float could be made in the shape of a disk, a substantial improvement might be expected.

Accordingly, a float having the shape shown in Fig. 4 was made. Being inherently unstable, the disk had to be guided, so cylindrical portions of small diameter were provided above and below it to give good separation of the guide points and to prevent binding. This float was a gratifying success in that it immediately reduced the viscosity effect to less than 25% of that shown in Fig. 1. However, the float was almost useless from a practical standpoint since its weight was only a small fraction of the weight of a standard float and the throughput capacity of the rotameter was therefore reduced to a small fraction of that of a standard rotameter. Efforts to gain weight by either increasing the thickness of the disk or the diameter of the vertical cylinders were fruitless, for these expedients caused a sharp increase in the effect of viscosity. It soon became apparent that a radical departure from conventional rotameter design was necessary to obtain both good stability against viscosity change and a reasonably high throughput.

Therefore a float was made up (for a ¾" rotameter at first) in which the disk forming the flow restriction and the "body" required to give the necessary weight were separated and attached to opposite ends of a tube of small diameter. (See Fig. 5.) The "body" of the float is completely removed from the flow stream of the fluid and is located in a pocket of stagnant fluid having no velocity and, therefore, no viscous drag. There is, of course, some viscous drag along the connecting tube, but since the tube is of relatively small diameter it presents little drag surface to the fluid. As the small diameter of the connecting tube also results in lowered fluid velocity, the viscous drag (which naturally varies with velocity) is further decreased.

The improvement obtained with this float (since designated "Stabl-Vis" Float) was startling. Fig. 6 shows the results obtained, compared with the data from Fig. 1. While the oil tests on the old-style floats were run with temperatures of 120°F. and 90°F., the viscosity effect was so reduced with the "Stabl-Vis" float that, to obtain a reasonable degree of separation between curves, temperatures of 120°F. and 77°F. were used. Since the temperature reduction from 90°F. and 77°F. increased the viscosity from 44 centistokes (205 S.S.U.) to 65.5 centistokes (305 S.S.U.) it is apparent that Fig. 6 does not even adequately represent the improvement obtained. Flow coefficient is plotted versus Reynolds number for the same float in the curve marked "Size 5" of Fig. 7; the dotted-line curve, from Fig. 2, is included for comparative purposes. While this particular "Stabl-Vis" float gives neither an entirely horizontal nor an entirely straight line, the improvement represents one practical solution of the problem and points the way to the correct solution.

In view of the fact that larger rotameters of the old type were known to be less affected by viscosity variations than smaller rotameters, and also gave smoother curves of coefficient versus Reynolds number, it was decided to continue the experiments with a 2" rotameter (Size No. 9). The shape of the ¾" "Stabl-Vis" float had departed somewhat from the ideal because of mechanical limitations and it was felt that a float of larger size might give better re-

scales due to elimination of this objection. Tests run under the same experimental conditions as the ¾" rotameter tests showed that the effect of viscosity was reduced to approximately 50% of the effect on the ¾" rotameter. A plot of flow coefficient versus Reynolds number (curve marked "Size 9" in Fig. 7) showed closer approach to a straight horizontal line with smaller variation in coefficient value.

It now appeared that the development had progressed to a point where values of C were becoming definitely predictable, permitting use of the Schoenbuorn-Colburn equation for the solution of all rotameter problems, provided that the factor $\sqrt{[(\rho_f - \rho_w)/\rho_w]}$ representing the effects of float and fluid density in the equation, were found to reflect accurately the conditions found in practice. It happened that the Naval Aircraft Factory was questioning the correctness of the density factor, so tests were made on a size No. 8, 1½" rotameter which was ready for delivery to the Navy. Two "Stabl-Vis" floats of identical dimensions, one of stainless steel (specific gravity 7.92) and one of aluminum (specific gravity 2.7) were made for this rotameter. With this large difference in density observational errors could hardly complicate the results. Calibrations were then run with both floats, each being tested with gasoline of specific gravity 0.72 and water at 112°F. Again the large difference in densities eliminated observational error as a serious factor. The water was heated to 112°F. so that its viscosity would be the same as the viscosity of the gasoline at room temperature, thus eliminating viscosity effects from the picture. After the capacities of the rotameter under the four different test conditions had been ascertained by actual calibration they were also obtained by calculation, using each of the four sets of calibration figures in turn to calculate the capacities under the other test conditions. The calculated and observed results were in sufficiently close agreement to leave no doubt that the factor $\sqrt{[(\rho_f - \rho_w)/\rho_w]}$ could be used for "Stabl-Vis" floats without any supplementary factors or exponents. Table I compares the actual flow readings obtained with the stainless-steel float in water and the calculated results for this float in water determined from the tests of the aluminum float in gasoline. Although the calculated correction factor was 240%, the worst variation between calculated and observed results was less than 6% while four of the six readings showed errors of less than 2%. When it is considered that these tests were run hurriedly on a Saturday morning with vapor bubble formation on the floats (due to a faulty setup) and with no opportunity to check results because of shipping requirements, the relatively good agreement obtained

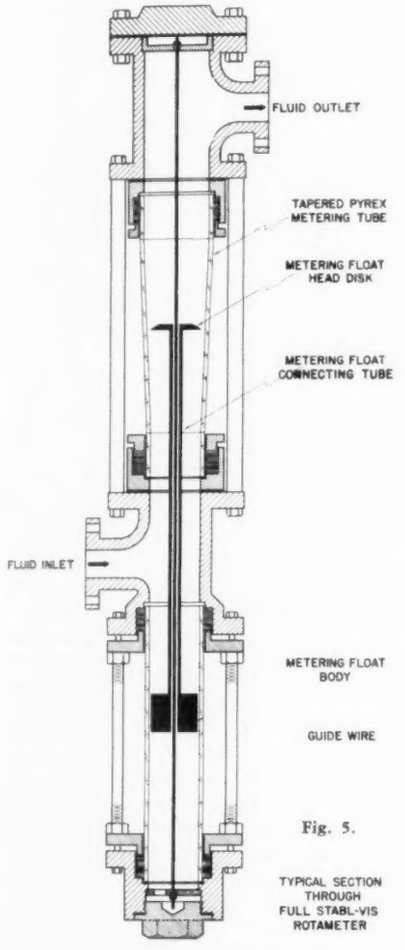


Fig. 5. TYPICAL SECTION THROUGH FULL STABL-VIS ROTAMETER

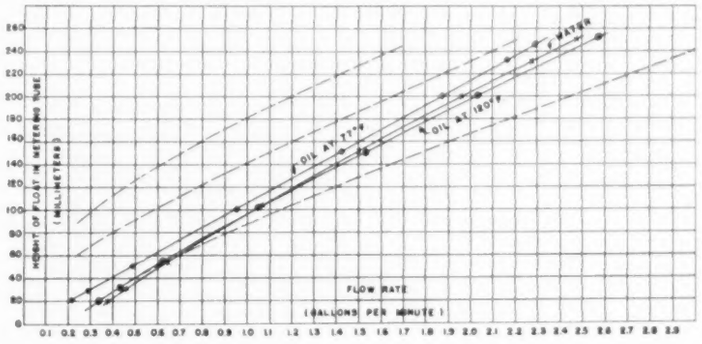


Fig. 6. Calibration curves for Size 5 Rotameter with "Stabl-Vis" float tested with oil and water. (Data from Fig. 1 included as dotted lines for comparison.)

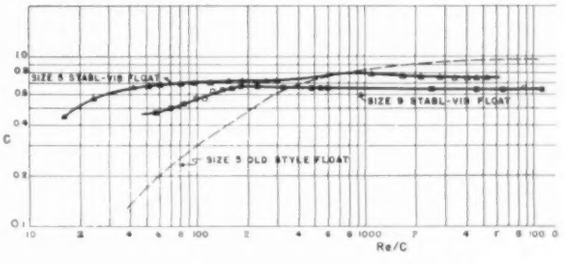


Fig. 7. Rotameter coefficients vs. Reynolds numbers for experimental and for "Stabl-Vis" floats. (Data from Fig. 2 included as dotted line for comparison.)
Multiplication factor to obtain (4) from (2) = 2.402

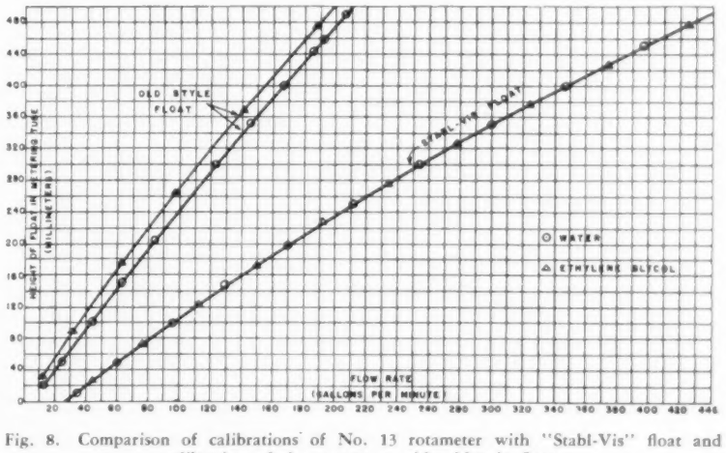


Fig. 8. Comparison of calibrations of No. 13 rotameter with "Stabl-Vis" float and calibration of the rotameter with old-style float.

TABLE I.

(1) Float Height in Tube mm.	(2) Aluminum Float in Water g.p.m. Observed	(3) Stainless Float in Gasoline g.p.m. Observed	(4) Stainless Float in Gasoline g.p.m. Calc.	(5) Error of Calc. Results Percent
10	0.495	1.263	1.19	—5.9
50	1.227	3.055	2.945	—3.3
100	2.163	5.28	5.20	—1.5
150	3.2	7.67	7.69	—0.1
200	4.26	10.19	10.23	+0.5
245	5.31	12.55	12.77	+1.8

seems to leave no doubt that the factor may be safely used as is, provided that the floats have the "Stabl-Vis" shape.

An opportunity now presented itself to run further experimental tests under still more interesting conditions. Rotameters for measuring the flow of ethylene glycol in the cooling systems of liquid-cooled aviation engines were being supplied to the manufacturers. As the viscosity of ethylene glycol varies considerably with temperature, and both temperature and percent concentration vary considerably in operation, an extensive series of calibrations had previously been required. Such calibrations were quite difficult to run since the vapors produced from flows of as high as 200 g.p.m. ethylene glycol at 230°F. prevented any one group of men from working in the calibrating room for more than short periods of time. Therefore, when a new order was received calling for a capacity increase to 400 g.p.m. it was decided to build the rotameter with a "Stabl-Vis" float and to run calibrations with water and with cold ethylene glycol and compare the results before attempting any hot tests or tests with mixtures of ethylene glycol and water. For purposes of comparison Fig. 8 shows the results of the new rotameter calibration and of the last previous calibration with ethylene glycol of specific gravity 1.1075. As the water calibration has been corrected to a specific gravity of 1.1075, the difference between the two curves represents only the effect of the viscosity change from 1 centistoke for water to 15.7 centistokes for ethylene glycol at the test temperature of 77°F. When the new 400-g.p.m. "Stabl-Vis" rotameter was tested in the same manner, the plotted points for water and ethylene glycol fell on the same curve.

Some of the results obtained in the main series of these investigations seemed to indicate the desirability of devoting some study to the effect of inlet piping arrangement on the calibration of rotameters. It has been customary to assert that the rotameter is not affected by the valves, bends, and similar turbulence-creating fittings in the piping adjacent to it. This has been true in that "errors" of 1% to 2% were hardly noticeable and of little importance in the ordinary process-industry applications—those not involving metering of volumetric quantities. However, calibration changes of 1% to 2% are frequently obtained with floats having the hitherto standard shapes. It was now found possible to develop float shapes which magnified this effect and which showed calibration deviations of as much as 10% if two 90° elbows were inserted in a previously straight supply line to a rotameter. Other floats were designed and tested which showed no change in calibration regardless of what was done to the inlet piping. The "Stabl-Vis" floats fall into this latter "immune" class. The test system used was capable of detecting flow rate errors as small as 0.25%.

Utilization of Results

It appears then, that this new method—the separation of disk and weight—permits viscosity to be eliminated as a factor to be considered in the calibration of rotameters for normal viscosity variations encountered in the process industries. The implications of this improvement are more than may, at first, meet the eye. Among the more obvious benefits the most immediate is, of course, that rotameter users may now switch individual rotameters from one service to another and still be able to rely on the accuracy of the flow readings they obtain. Secondly, it becomes unnecessary for rotameter users to ship bulky (and frequently expensive) samples of their viscous fluids to the rotameter manufacturer's plant and they will not be put to the expense and delay of special calibration of individual rotameters with these samples. Thirdly, the problem of making the floats resistant to corrosion is simplified. For example: it is less expensive to take a tantalum disk and tube and a lead-loaded tantalum cylinder and weld them together to make a "Stabl-Vis" float than to spin a tantalum sheet to the typical dimensions of an old-style float. It furthermore is possible to use composite construction, making only the disk, which must bear the brunt of the corrosive attack, of some highly corrosion-resistant but perhaps expensive material while using a less costly material for the extension tube and the weighing cylinder. Fourthly, materials which could not previously be adequately metered by reason of viscosity peculiarities can now be handled accurately. For eexample, sulphuric acid, because of its sharp variation of viscosity with both temperature and concentration, has been difficult to meter accurately; it no longer presents a problem.

A fascinating new possibility for the new rotameter lies in its use as a continuous viscometer and a continuous pycnometer. Obviously it is necessary that the flow rate through a rotameter designed to measure viscosity or density be held constant since otherwise the float position would not be affected by viscosity or density alone but by a combination of viscosity and flow rate or density and flow rate. Furthermore, the rotameter designed to measure density changes must not be affected by viscosity changes nor may the rotameter designed to measure viscosity changes be affected by density changes. In the past it has proven almost impossible to hold the flow rate constant or to prevent combined effects of viscosity and density changes. With the new float these problems can be eliminated. If the viscosity of a fluid flowing in a pipe line is to be determined, a small stream can be by-passed through a "Stabl-Vis" rotameter. By means of a manual control valve the float can be held at a constant position, insuring constant flow rate despite viscosity changes. In series with the "Stabl-Vis" rotameter there can be a second rotameter whics acts as the viscometer. It would be equipped with a cylindrical plug float, the position of which would vary greatly with viscosity. This second rotameter can be calibrated in terms of viscosity since the flow rate through it is held constant by means of the first rotameter. If the specific gravity of the fluid may vary and it is desired to measure it continuously, a third rotameter can be placed in series with the first two. The float in the first rotameter, in addition to being of "Stabl-Vis" design, would then be made of, or loaded with, a dense material (mercury or tantalum) so that the effect on it of changes in fluid specific gravity would be small. The second rotameter's cylindrical plug float would also be a high-density float, so that the viiscosity readings would not be distorted by specific gravity changes. The float in the third rotameter, while of "Stabl-Vis" shape to eliminate viscosity effect, would be made of a light material so that its position would be considerably affected by changes in the specific gravity of the fluid. Thus, on a single small panel, flow rate, viscosity, and density could be read continuously, using simple, inexpensive equipment. The by-passed fluid stream, after passing through the rotameters, would be discharged back into the main stream. It is hoped that here, perhaps, a totally new field of usefulness for rotameter may be found.

Conclusion

It is intended that the work described in this article shall represent only a first step in the further development of the rotameter type of flow meter. When the hundreds upon hundreds of published research papers on orifice and other flow meters of the "head" type are considered in comparison to the dozen-odd available publications on rotameters and similar flow meters of the "area" type, it seems an inescapable conclusion that further basic improvements in the rotameter will result from a continued research program now under way.

Acknowledgments

The writers wish to express their thanks to Messrs. Colburn and Schoenborn of the University of Delaware, Whitwell of Princeton University and Rushton of the University of Virginia for the help and advice given during the progress of this work. Particular thanks is due Mr. H. G. Neale of the Aeronautical Engine Laboratory of the Naval Aircraft Factory at Philadelphia who has made numerous valuable design suggestions and who has on many occasions painstakingly checked the results of changes both in design and operation methods in his laboratories.

A Combination Visual and Autometric Method of Optical Pyrometry

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Research Engineer, Stackpole Carbon Co., St. Marys, Pa.

I. Introduction.

HIGH-TEMPERATURE measurement and control have been handicapped by the scarcity of methods for use in the temperature range of 1200°C. to 3000°C., which would have the same adaptability, accuracy and usefulness in their industrial embodiments as the usual thermocouple pyrometer. There are methods of measuring temperatures in this range, but those which may be adapted for indicating and controlling these temperatures do not always have the desired accuracy. A method has been worked out of combining two of the usual methods of measuring these high temperatures in a manner that is highly accurate (as will be shown) and also readily adaptable and convenient for controlling and recording. The two known instruments utilized are the disappearing-filament type of optical pyrometer and the photoelectric cell. These elements

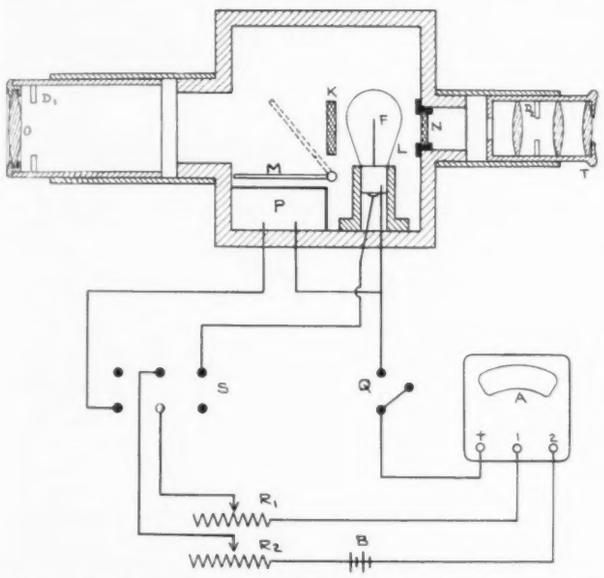

Fig. 1. Schematic Diagram of the Photoelectric Optical Pyrometer with Built-in Disappearing-filament Pyrometer for Checking.

are combined in such a manner that use is made of the most desirable attributes of each. The optical pyrometer is the most accurate method for measuring temperatures in the range of 1200°C. to 3000°C., and this accuracy is used and maintained in the instrument. The photoelectric cell measures the intensity of the light emitted by the hot source and can transmit a continuous record of this intensity for controlling or recording. A circuit is described which has been found to give satisfactory operation in service where close control of temperatures in the high range is necessary.

II. Description.

A schematic diagram* of the instrument in one form is shown in Fig. 1., in which O is the objective lens focussing the light from the body whose temperature is being measured on filament F of calibrated lamp L. T is a 10-power microscope which is also focused on the lamp filament F; and D_1 and D_2 are diaphragms adjusted to give the proper apertures for the best disappearance of the filament[1] and greatest accuracy of the optical pyrometer. K is the neutral absorbing screen[2] which may be swung in or out of position to increase the range of the optical pyrometer since the lamp L should not be operated above a brightness temperature of 1500°C. The screen N[3] is used to filter out all but the red light. While it permits a certain band of wave-lengths to pass, the effective wave-length (screen and human eye) is 0.66μ. M is a mirror which may be swung into the position shown by the dotted lines to deflect the light from the source to photocell P. The leads from the photocell and the lamp are connected to double-pole double-throw switch S which is mounted inside the case of the instrument and which is operated by the motion of mirror M to switch in either the lamp or photocell, depending upon the position of the mirror. A is an ammeter with two scales, 1 and 2. On the instrument now in operation, scale 1 is 0-30 microamperes and it is used to measure the photocell current. Scale 2 is 0-750 milliamperes for measuring the current in the optical pyrometer lamp L. B is the battery which furnishes the current for lamp L; and R_2 is a rheostat placed in the circuit to regulate this current. Rheostat R_1 is used to adjust or standardize the photocell current. Switch Q is used to open the circuit when the instrument is not in use.

The instrument is mounted conveniently on a base which permits the axis of the instrument to be rotated in any direction, to be tilted from the horizontal position by about 20° and to be raised or lowered. The milliammeter is mounted in a box with the batteries, the rheostats and the switch for opening the circuit.

The optical pyrometer is calibrated with a standard lamp at six temperatures in the range of its operation. The values of the temperature for all values of the current are then calculated by means of well-known methods to give the calibration table for the instrument. Using a Weston Model 622 milliammeter, it is possible to read brightness temperatures on this instrument to within ±10°C. in the range from 850°C to 1550°C. The accuracy of the higher ranges is not as great since the temperature range is expanded by the neutral screen for the same filament current range.

III. Operation.

The instrument was designed originally for use as an indicator with which the operator could manually control the temperatures in certain processes. Although its use is not limited to these conditions, a description of this type of operation will be sufficient to point out the main characteristics of the instrument.

The pyrometer must be set up so that the aperture at O is filled with radiation from the source to be measured and controlled. It is not necessary, however, that the hottest sections of the source completely fill the field of vision. The instrument is adjusted to superimpose the image of the source on the filament of the lamp. If a certain temperature is desired for the work in progress, it is heated up until it reaches this temperature as measured by the optical pyrometer. The temperature is kept at this point manually until all the parts (of the tube furnace or measuring tube) which may radiate into the aperture O come to equilibrium. The mirror is then swung into the position where it interrupts the light from the source and reflects it to the photocell. The circuit is automatically changed over and the milliammeter now reads the photocell current. For purposes of control only, all that need be done is to hold the photocell current constant. Rheostat R_1 may be used to adjust this current to some reasonable value.

Giving time for initial change in the output current of

*Patent No. 2,230,438, issued Feb. 4, 1941.

[1]Traité de Pyrométrie Optique. G. Ribaud. Paris, 1931, Page 293.

[2]Corning Glass No. 390 Pyrometer Brown.

[3]Corning Glass No. 241 H. R. Pyrometer Shade Red.

the photocell and correcting for this change, it has been found possible to check the temperature at the end of a four-hour run to within the limits of accuracy of the optical pyrometer itself. Thus, the Weston Photronic cell, which was used for this work, appears to have the stability and sensitivity to changes in light intensity required for this type of service.

IV. PHOTOCELL CHARACTERISTICS.

Since a resistance is used in series with the photocell to adjust the value of the current, the output-temperature characteristic of the photocell has been measured as a function of the resistance in series with the cell. By output-temperature characteristic is meant the current in the photocell measured as a function of the temperature of the source and of the resistance in series with the cell. Certain parts of this problem have been discussed by Larsen and Shenk[4] and the points mentioned by them will not be repeated. It is interesting to note, however, that the use of resistance in series with the cell suggests an interesting simplification in the use of the Weston Photronic cell for measurement and control of temperatures.

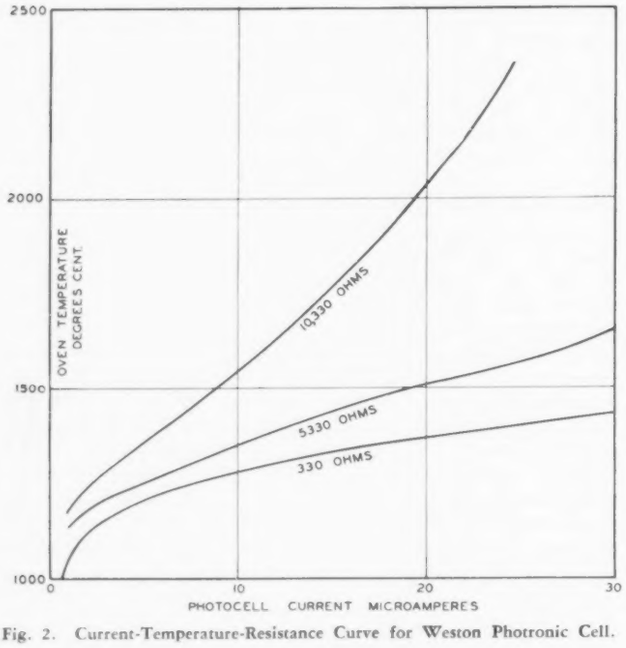

Fig. 2. Current-Temperature-Resistance Curve for Weston Photronic Cell.

The instrument described in Fig. 1 was set up to measure the temperature in a carbon-tube resistance furnace (inside diameter 1½") which could be heated to about 2300°C. It was sighted upon a graphite block placed in the center of the tube. (Otherwise, the photocell would be measuring the light from the "cold" far end.) The carbon tube was packed in lampblack to protect it from oxidation and hydrogen was passed through it to keep the atmosphere clean. It was heated to well above the range of temperatures being considered, until all of the volatile materials in the carbon and lampblack were driven off.

The photocell current was measured as a function of the temperature of the center of the oven for the different values of series resistance as shown in Fig. 2. The resistance of the microammeter used to measure the current is included in the values shown in Fig. 2. The values are thus the total resistance external to the photocell.

The interesting points to be noted are: First, that the sensitivity is decreased considerably when the external resistance is increased. For low values of external resistance, a relatively small increase in temperature gives a relatively great increase in current. Secondly, it is to be noted that for an external resistance of approximately 5300 ohms, the temperature current relation is practically linear over a wide range of temperatures*. This fact may be used in the design of recording and controlling equipment for temperatures in this range, since it permits the use of linear scales and charts.

If the proper external resistance for linearity is used, it will no longer be possible to adjust the photocell readings to certain standard values by means of this resistance. It is possible, however, to standardize the readings by using an iris diaphragm or some other limiting device in front of the photocell. The readings may then be adjusted to the standard values without affecting the calibration of the photocell.

V. SENSITIVITY AND ACCURACY.

Examination of Fig. 2 will show that by using a microammeter with a range of 0-50 ma., the sensitivity will be well within 8°C. A high-grade laboratory microammeter with long mirror scale permits reading temperatures to about 2°C.

But these sensitivity figures do not necessarily imply a corresponding order of accuracy. In the first place, they refer to brightness temperatures, so that accuracy of determination of true temperatures will depend (as always in radiation and optical pyrometry) upon exact knowledge of emittance corrections. In the second place, accuracy will depend (as always in measurement practice) upon the number of sources of instrumental errors, the probability of their being additive, the accuracy of the reference standard used in calibration, the care taken in calibration, the frequency of calibration, etc.

The photocell is calibrated each time a set-up is made, the built-in reference standard being the visual optical pyrometer (previously calibrated against a standard lamp such as used at the National Bureau of Standards, which is accurate to 2°C. up to 1550°C.). Assuming additive instrumental errors, the accuracy of brightness-temperature measurement in the range 850-1550°C. immediately after a set-up is made is well within 10°C. Assuming a 5° error due to uncertainty of emittance correction, and adding it, the overall accuracy becomes 15°C. in that range. For the range 1550-2000°C., the sensitivity is lower and the numerical value of most errors has to be approximately doubled. It is believed that the limit of (instrumental) error in the higher range, with the instrument used at this writing, is well within 20°C. If a 10° emittance-uncertainty error is *added*, the total error at the high range becomes 30°C. This is a conservative figure. Larger errors could be expected, however, if the user neglected to take advantage of the built-in visual type pyrometer when a new set-up is made—and also after installation when the likelihood of photocell "drift" or "fatigue" is suspected.

VI. CONCLUSIONS.

An indicating optical pyrometer is described which combines the accuracy of the optical pyrometer with the adaptability of an indicating pyrometer. It may be readily adapted to measuring, indicating, recording and controlling any temperatures which can be measured with the optical pyrometer. An example is described which has had successful application in certain industrial processes in the temperature range from 1100°C to 2300°C. A method is also described of increasing the usefulness of the Weston Photronic cell by making the output-temperature relation practically linear throughout a wide range of temperatures.

[4]B. M. Larsen & W. E. Shenk. Temperature Measurement with Blocking-layer Photocells. *Journal of Applied Physics*, Vol. 11, August 1940, pages 555-560.

*Patent applied for.

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Air-inclusion Errors in Liquid-filled Thermometer Systems

By H. A. ROLNICK
Director, Trent Engineering Laboratories, Philadelphia

WHEN filling thermometer systems of the remote-indicating type the question often arises as to the effect of air left in the system. The longer the capillary tubing between the pressure spring and the bulb, the longer it takes to evacuate the system—particularly, if done through the pressure-spring end.

In a general way it can be seen that if there is present a cushion of air in the thermometer system, the thermal expansion of the thermometric liquid will be partly taken up by the compression of the air. And since the rate of compression is different for different pressures, there will result a distortion of the relation between thermal expansions of the thermometric liquid and movement of the pressure spring.

Below is given an analysis of this effect and formulae enabling one to predict the scale shape of a liquid-filled thermometer system containing some air.

The air trapped in a closed system will eventually work its way down into bulb or up into the pressure spring. The first analysis below is for the case where the air is located at a place in the system where temperature changes are small enough to be neglected.

Case I—Air Not in Bulb

Applying Boyle's Law to the trapped air,

$$\frac{dP}{P} = -\frac{dV}{V}$$

$$dV = -AadT + kdP$$

$$\frac{dP}{P} = \frac{AadT - kdP}{V} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

This yields on integration:

$$\frac{P_2 - P}{T_2 - T}\left[1 + \frac{P_1 V_1}{kP_2 P}\right] = \frac{aA}{k} \quad . \quad . \quad . \quad . \quad (2)$$

If the expression in brackets were constant, then a linear relation would exist between a temperature change at the bulb and a pressure change in the system. On this basis scales are printed for such thermometers. The presence of the variable term P inside the brackets causes a distortion of the scale shape. If the relation between pressure and temperature is assumed linear, then this distorted scale shape gives rise to an error in the thermometer reading.

The expression for the error caused by included air, assuming the end points on the scale are correct, is as follows:

Error in percent of full-scale,

$$E = -\frac{100\, V_1\, (P_2 - P)\,(P - P_1)}{K\, P\, P_2} \quad . \quad . \quad . \quad . \quad (3)$$

Notation

A = Internal volume of the bulb.

a = Relative thermal expansion between bulb and liquid.

P,V,T refer to the pressure in the system, the volume of air in the system, and the temperature of the bulb.
(Subscript 1 refers to the values of these variables at the lowest temperature of the scale; subscript 2 refers to the value at the end of the scale.)

k = Ratio of volume change of pressure spring to pressure change in system.

K = Total volume change of pressure spring for a full-scale pressure change.

dP,dT are infinitesimal increments of pressure and temperature.

From the above, it can be seen that the error is proportional to the amount of trapped air, and is inversely proportional to the volumetric change in the pressure spring. The spring element with the minimum volumetric change has the largest errors due to included air.

An example of a typical system will be calculated to indicate the values involved. A mercury-in-steel bulb with an internal volume of 10cc. is evacuated to a pressure of 1mm. of mercury, then—

$V_1 = \frac{10\text{cc.}}{760}$ (Volume at atmospheric pressure)

P_1 = (Pressure at lowest temperature of scale) = 450 lbs./in.^{2}.

P_2 = (Pressure at highest temperature of scale) = 1500 lbs./in.^{2}.

K = 0.08cc.

TABLE I

Temp. °F.	*Corresponding Pressure*	*Error in Percent of Full Scale*
0	450	0
20	660	−3.0
40	870	−3.3
60	1080	−2.7
80	1290	−1.6
100	1500	0

The error (see Table I) is negative, i.e., the instrument indicates a lower temperature than actually exists.

For similar thermometer systems with wider temperature spans, the error will be smaller (for the same pressure of residual air). This is due to the smaller bulb used. Thus for a temperature span of 200°F., in the same system (but smaller bulb) as in the example above, the errors will be approximately one-half those shown in Table I.

Case II—Air in Bulb

In case the air is all driven into the bulb, the analysis for the error is somewhat different.

Using the same symbols as above and applying both Boyle's and Charles' laws to the gas at the bulb, the following equation is obtained:

$$\left(kP + \frac{RT}{P}\right) dP = (AaP + R)\,dT \quad . \quad . \quad . \quad (4)$$

where R = Gas Constant

Integrating the above gives finally:

$$P - P_1 = \frac{Aa}{k}(T - T_1) + \frac{V - V_1}{k} \quad . \quad . \quad . \quad (5)$$

From Equation 5 it can be seen how the pressure changes in the system are affected by the changes in volume of the

ONE of the "impossibles" of science is the attainment of a perfect vacuum. Therefore, some air remains in the "tube-system" (bulb, capillary tubing and pressure-spring) of a liquid-filled type remote-indicating thermometer, after the system has been evacuated and filled. This is true even in the factory of an experienced manufacturer. In such a factory, of course, there are not only *facilities* which permit nearly-complete evacuation but *methods* understood and enforced by foremen, so that the air-inclusion error is generally negligible. Mercury and organic-liquid pressure-spring thermometer are being refilled in an ever-growing number of plant instrument departments. Facts and figures on errors due to included air seem to be in order. Dr. Rolnick was formerly associated with the Brown Instrument Co.; his data are authoritative —M. F. BEHAR, *Editor.*

air in the system. The actual error, in percent of full scale, is given by the following expression:

$$E = -\frac{100\,[B(V_2 - V_1) - (V - V_1)]}{k\,(P_2 - P_1} \quad . \quad . \quad . \quad (6)$$

where $B = (T - T_1)/(T_2 - T_1)$;

or re-writing and substituting pressures and temperatures for the volumes,

$$E = \frac{-100\,V_1}{K}\left[B\left(\frac{T_2\,P_1}{P_2\,T_1} - 1\right) - \left(\frac{T\,P_1}{P\,T_1} - 1\right)\right] \quad . \quad . \quad (7)$$

Using the same values as in the example above, we get the following table of errors (Table II).

TABLE II

Temp. °F.	*Error in Percent of Full Scale*
0	0
20	−2.6
40	−2.9
60	−2.4
80	−1.3
100	0

For the wider temperature spans, the error is much less, falling off nearly as the square. That is, for a system with a temperature span of 200°F. (and a bulb volume half of that in the example above) the error (for the same pressure of residual air at the start) would be approximately one-fourth of the above.

Also if the residual air pressure were 10mm. of mercury instead of 1mm., the departures from straight-line calibrations would be ten times as great. Hence for practically all liquid-filled thermometer systems of the remote-indicating type, evacuation of the air from the bulb system is necessary for reasonable accuracy.

Part of the above-described work was done when the writer was with the Brown Instrument Company; and the writer wishes to thank the Brown Instrument Company for permission to publish this portion.

Installation, Care, Maintenance and Servicing

(Concluded from page 51)

moment it was received. Yes, we sign all slips 'O.K.' Yes, I know it makes it harder for the factory to spot inferior workers."

Case 5

Chief instrument engineer: "Process-control instruments are specified by the theoretical engineers at the mahogany desks downtown. They re-order the same type and model of the same make year after year. It was not the best available control system for the process when it was first specified; it certainly is 'way out of date now; but these brass hats wonder why we can't get the same results as our competitors."

Case 6

Another chief instrument engineer: "We have brass-hat trouble too, but of a different kind. They order the latest models after studying their characteristics; then they don't even send us the instruction sheets. They expect us to know as much as the instrument-company engineers who designed the controllers."

Case 7

Research director of a processing company: "In one of our departments there are ten units, each with an air-operated temperature controller. These were correctly specified and installed. The men in that department learned so much from the charts that they acquired sufficient skill for manual control of one unit when one of the controllers got out of order for lack of maintenance. Then, in the course of years, another controller went out of order, and others, until only two or three were actually functioning. The process in that department is such that lack of automatic control, though costly in the long run, does not noticeably impair quality when skilled men are on the job, although there is a sinful waste of fuel, electric energy and certain raw materials. A few weeks ago, an instrument-company engineer who made a call in another building dropped in to ask whether these controllers, installed years ago, were all functioning perfectly. The department head said they were. He and his men were too busy to fix the controllers themselves, and he did not want to suddenly tack on a repaid-cost item which would get him in dutch with the treasurer. I told him that if he ordered the instrument company's service men to clean and repair all the controllers I would back him up and would guarantee that the result would be a sharp drop in fuel and other running expenses, for which *he* would be credited. The controllers were serviced and the running expenses took a big drop."

Case 8

Instrument-company sales engineer: "The users who would most benefit from this discussion are the ones who are not here and who would not come if asked, because they do not take enough interest in their own instruments. With a typical user of that kind, one of our men has to make a trip to install every instrument received except the portable ones. If it is an air-operated controller, we have to make a second trip to turn on the air, and then a third trip several days later, when the processing equipment is started up."

Case 9

Another instrument-company engineer: "Believe it or not, we had to send a man twenty miles out of town and all the trouble he found was that a steam valve had not been opened because the instructions did not mention it. The user no doubt thought that our controller would open this *hand* valve by some sort of magic."

Case 10

Instrument-company branch manager: "We have a small plant as a satisfied customer because their attitude is the opposite: They appreciate the value of instruments but the only work they do is to change charts. They pay us a fixed periodical service fee for keeping them in good condition. This kind of an arrangement is possible only where the user has confidence in us. If our service man found an instrument accidentally damaged, an over-suspicious user might claim that no one touched it, that it went bad by itself and that we should make factory repairs without increasing our regular service-call charge."

Case 11

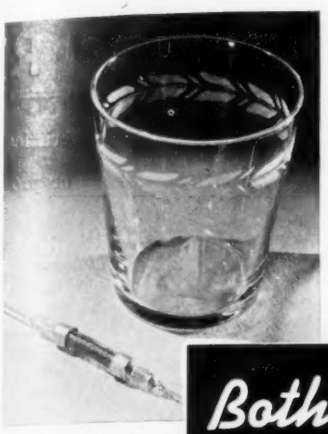
A member: "Users ought to know better than to rate instrument companies by the size of their local service organizations. This size is governed by a number of factors. I am reminded of a woman who refused to buy a high-grade refrigerator because that company has only one service truck in Pittsburgh. She bought another make because that other company has *sixteen* service trucks. She thought that the well-known company was snooty and that the other company voluntarily gave super-service to its customers."

Case 12

Instrument-company district manager: "Much depends on how long an industry has been using industrial instruments. Old customers with large instrument departments save us money by attending to many details themselves. When they send for us, it is out of the ordinary. We frequently omit time charges and other items. An accountant would discover a loss. An accounting system however, should allow for the benefit derived by us, as well as by the user, from exchanging ideas on new problems. That is one of the ways in which Instrumentation is advanced."

* * *

At the conclusion of the discussion, it was the consensus that such cases and many others should be written down, classified and analyzed, and that such data should be compiled informally in all industrial centers and likewise made public, so that out of the accumulation of facts, certain *general* truths could be distilled. The A. S. M. & C. will hold at least one more "bull session." We suggest that local groups of instrument men in all sections of the country hold similar informal discussions and have their secretaries jot down for *Instruments* the constructive ideas that emerge.—M.F.B.



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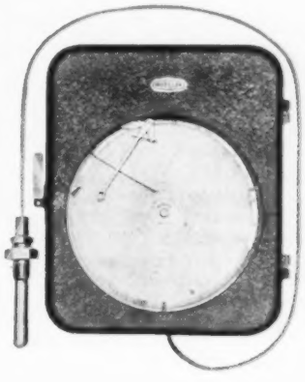

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LETTERS TO THE EDITOR

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To the Editor of *Instruments*:

On the subject of the article by Technical Staff Abbotts Dairies, Ltd., in the November issue of your magazine I make bold to submit a brief discussion:—

These writers mention the apparently mysterious fact that the ice cream is one-half degree colder in the common pipeline header than as it leaves the freezers. While the quantities involved are not given, a fairly simple explanation appears.

The mixture of ice cream and air (proportions unknown) leaves the freezer at a temperature of 22°F. and 70 lbs. gage. The pressure in the common outlet line is also unknown, but it most probably won't exceed 30 lbs. gage. Expansion ratio is (70 + 14.7)/(20 + 14.7). Using the standard formula for adiabatic compression we find that the temperature drop of the air alone, expanding over this range, will be from 482°A. to 401°A, or a net drop of 81°F. This would bring the temperature of the air alone down to about 59°F. below 0. Of course, it absorbs heat from the cream, thereby slightly lowering the temperature of the whole mass.

November 29, 1940 WM. H. SAYLER

An Early High-frequency Prime-relay Control System

AMERICAN GAS FURNACE CO.
ELIZABETH, N. J.

To the Editor of *Instruments*:

Your distinction between "electrical" and "high-frequency electrical" control systems in the November *Instruments* is a worth-while contribution to the art; but the dates you cite convey an erroneous impression—which needs to be corrected.

It was in 1928 that the idea of causing a measuring device (or its equivalent) to effect proportioning control by affecting the capacity of a suitable electric circuit took form. Its development resulted from an endeavor to attain higher accuracy in the control of temperatures indicated by sensitive instruments of the moving-coil type. Through experience gained in aiding my father in his experiments, it was soon realized that if a control system was to maintain a given temperature accurately, it would have to be capable of effecting a complete *balance* between the fuel input and the heat losses of the furnace or appliance.

With systems where the fuel regulation is governed by steps, either too much or too little is supplied to balance the losses at a given moment, with the result that the temperature will oscillate between two limits. While proportioning control could and was easily attained in systems employing rugged measuring devices such as are customarily used for temperatures below 1000°F., its attainment in systems employing sensitive moving-coil type instruments was quite a different matter. These instruments, used in conjunction with a thermocouple, must operate on less than 50 mv. and are sometimes required to give full-scale deflection on 20 mv. or less. The inadvisability of burdening such delicate devices with additional mechanisms of any sort is apparent.

It was felt that in order to secure the desired qualities, a system possessing all of the following characteristics combined would have to be developed.

1. A means whereby the slightest deflection of the indicating element (or its equivalent) is detected and made to directly cause a relative change in control energy.
2. A non-mechanical linkage between the indicating element and the control apparatus whereby the former may perform its primary function without encumbrance.
3. A system through which extreme control sensitivity may be attained, which may, however, be adapted to specific requirements.
4. Extreme flexibility as to other control characteristics such as taper, "automatic-reset," etc.
5. Ease of application to a variety of conditions or processes.
6. Simplicity.

The importance of the above six characteristics will now be explained:—

Unless a control system be directly and minutely responsive to the slightest change in an indicated condition, the system cannot be said to be steplessly proportional in character. In order that a true balance between the demand and the corrective energy be struck, a corrective influence must be effected immediately, upon the slightest change in trend of the condition under control. If any lag is present between the indicating element and the control system governed by this element's movement, the beforementioned state of complete balance cannot obtain.

Aside from the lag introduced by any mechanical system of linkage, the inadvisability of burdening a sensitive instrument movement with a secondary function and subjecting it to influences detrimental to the fulfillment of its primary function, is obvious.

Where little or no time lag is in evidence, the higher the control sensitivity, the greater the precision of regulation will be. Furthermore, unless the system is isochronous in character, the point of balance may be in variance with that desired, and for which the index has been set, when the system is applied to conditions subjected to variations in load. However, if sufficiently high sensitivity is employed, the control zone becomes so narrow that the error so formed may be neglected. In cases where time lag such as thermal lag in pyrometry is encountered, it becomes necessary to adapt the degree of sensitivity to the magnitude of lag. If this procedure is not followed, "hunting" will result due to the delayed corrective action initiated by the indicating element's passing through the control zone. Under such circumstances, the proportioning characteristic is lost and the control becomes, in effect, a two-position control.

An important factor influencing the applicability of a control system to a variety of processes and conditions, is the ease with which special control characteristics may be engineered into it. Aside from degree of sensitivity and isochronism, the importance of which has already been touched upon, it is often desirable to distribute the sensitivity of response over the control zone according to a specific taper.

The method of linking the control system to the indicating means must be of such nature that it can be readily applied to the many different indicating or measuring devices used in determining the state of various processes and conditions. If the means of linkage is too bulky or complicated and requires too many changes in the original design of the indicating device, both the design and the cost of the unified system will be adversely affected. The ease with which the system may be adapted to a multitude of indicating devices, is, therefore, a good measure for its general applicability.

To assure long, dependable operation with low maintenance expenditure, a control system must incorporate a minimum of complexities. The design should be such as to permit immediate replacement of the few elements that are necessarily subject to deterioration. Such elements should be of standard design, allowing them to be readily procured at low cost at any time or place.

Though electronics had not invaded the industrial field at that time, attention was directed toward it in attempting to satisfy the above requirements. It was thought that the easiest way by which a great variety of indicating devices could affect the output of a suitable electronic circuit was by initiating changes in electrical capacitance. By this means a non-mechanical lag-free linkage affording regulating energy directly responsive to the indicating element's movement, is effected. Most indicating devices incorporate a moving element which is a conductor of electricity, thus enabling it to serve as one side (usually ground) of a variable capacitor. In such cases, it is but necessary to introduce one electrode of proper design to serve as the other side of this capacitor. By varying the form of the electrode or its relation to the moving member, or both, the capacity changes produced may be confined to any desired zone of

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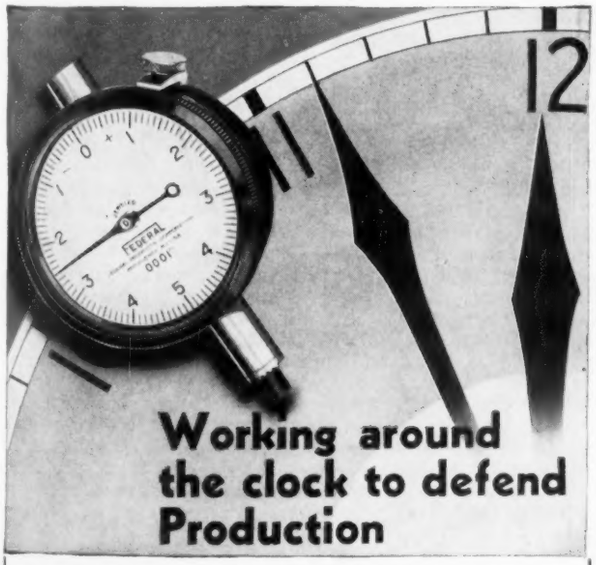

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Fig. 1

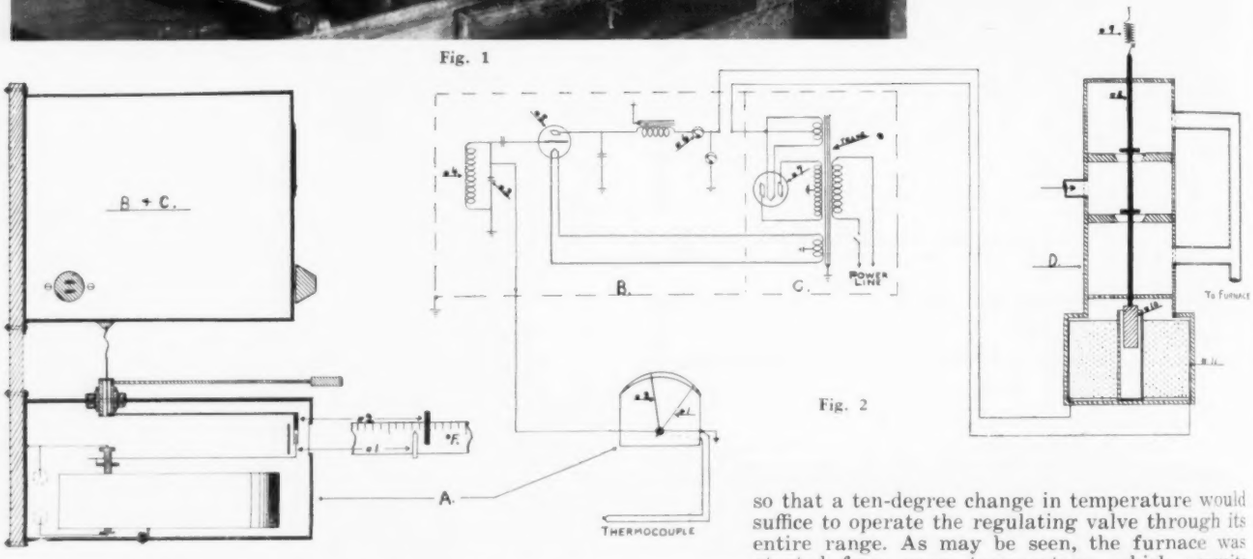

Fig. 2

the member's travel; and they may be made to conform to any predetermined taper. Other control characteristics such as sensitivity, isochronism, etc., are, of course, determined by the design of the electronic circuit and the regulating means employed. In cases where the moving element of the indicating device is necessarily a non-conductor, it effects capacity changes by altering the dielectric of a properly designed and situated "fixed" capacitor. An idea as to what may be expected of such a system may be gained from the accompanying illustrations of experimental models.

Fig. 1 portrays an early "bread board" model utilizing a 210 tube as an oscillator in a circuit somewhat similar to that shown in Fig. 2. A pyrometer movement connected to a thermocouple may be seen in the right foreground of the photograph. An insulator supporting a thin strip of metal serving as the stationary plate of a capacitor is so arranged that the indicating needle, serving as a "rotor," will pass immediately beneath the strip at a predetermined point in its arc. In so doing, the indicating element's movement in the proximity of the "stator plate" will vary the capacity in the oscillator circuit, thereby affecting the plate current of the tube. Since the solenoid-operated valve is in series with the plate supply, the valve will open or close in direct relation to the movement of the indicating needle. While this circuit is quite primitive, it nevertheless served its purpose in proving the feasibility of this kind of control.

Fig. 3* shows a later model employing the circuit of Fig. 2 in a double (or push-pull) arrangement. It was subsequently found that entirely satisfactory results could be obtained from a single-sided arrangement upon which the unit was so operated. The specially designed solenoid-operated furnace regulating valve may be seen in Fig. 4.*

The performance of this apparatus under actual operating conditions may be judged upon inspecting Fig. 5*, which shows a temperature record produced by a well-known make of recording instrument, of a standard hardening and tempering furnace under control. The sensitivity, in this case, was adjusted to obtain a controlling zone of 10°F., *i.e.*, so that a ten-degree change in temperature would suffice to operate the regulating valve through its entire range. As may be seen, the furnace was started from room temperature, which permits the demonstration of the control's responsiveness by observing the slight though definite upward trend in temperature during the soaking period. This effect is explained by the fact that as the furnace walls become heated through and a thermal balance between the inner and outer surfaces is approached, the fuel demand for maintaining a given temperature is progressively reduced. Since, with such a system, the fuel supplied to the furnace varies inversely as the temperature, the temperature must rise in order to effect the necessary decrease in the fuel supply. A further demonstration of regulating ability is seen in the contour of the "loops" occasioned by the insertion of cold material. By proper placement of the thermocouple in relation to the furnace charge, the work is brought to temperature in the shortest possible time without danger of overheating, since the fuel input is always proportioned to the demand from minimum to maximum.

Though the ability of this system to render superior performance was demonstrated and realized prior to 1933, its field of application was still more or less limited to the laboratory. With the "home-made" circuit of Fig. 2, the replacing of the oscillator tube usually meant rebalancing the entire system. While seeking aid in the solution of this difficulty, I made the acquaintance of Mr. F. H. Shepard, Jr., of R.C.A., whose thorough understanding of electronic circuit design and generous coöperation have been of inestimable value to me ever since. I owe both him, as well as the progressive company he serves, a great debt of gratitude.

Figs. 6* and 7* illustrate progressively later models of the system employing Mr. Shepard's circuits. Fig. 7* shows a control in which a standard Minneapolis-Honeywell motor-operated proportioning valve with a special potentiometer, replaces the solenoid-operated valve.

February 4, 1941 GEORGE A. F. MACHLETT.

*EDITOR'S NOTE—Figs. 3, 4, 5, 6 and 7 would require approximately two full pages, unless reduced so much that details would be lost. *Instruments* believes that giving space to the *full* text of Mr. Machlett's communication and to his Figs. 1 and 2, is sufficient. Personally, as the author of the article on classes of temperature control systems in the Nov. 1940 *Instruments*, the writer stands corrected with regard to the history of the "capacity" type in the "high-frequency" class.

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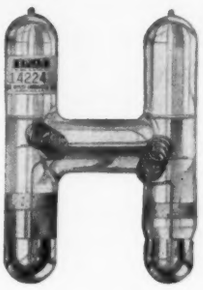

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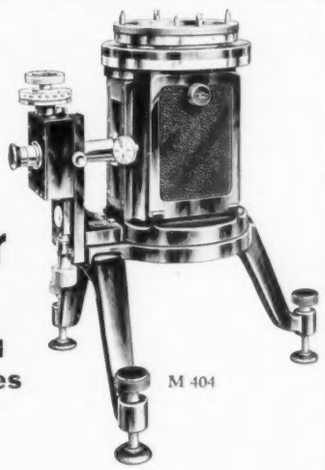
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EDUCATION and TRAINING—BRIEF ITEMS

Appoints Self "Committee of One" to Have Western Colleges Recognize Instrumentation

THE DENVER FIRE CLAY COMPANY
OFFICE OF TEXAS CORPORATION
EL PASO, TEXAS

Gentlemen:

This writer has been devoted to your magazine for years, since you first started and I eagerly look for each new issue.

I have somewhat appointed myself as a committee of one, towards seeing that our few western colleges receive proper recognition from the east and when the preliminary report on Survey of Curricula appeared on pages 42 and 43 of Volume 14, February, 1941, No. 2 issue, I was disappointed to see that the University of New Mexico at Albuquerque, New Mexico School of Mines at Socorro, New Mexico and Texas College of Mines at El Paso were completely left out, and only two entries under the University of Arizona.

In the last two years the schools mentioned have bought considerable new equipment and strengthened their faculty, particularly Socorro and therefore qualify under some of your headings. I have a personal letter from President C. E. Needham of the New Mexico School of Mines, stating that according to his records they did not receive your questionnaire. They probably qualify more than any of the other schools in certain groups.

As a favor to me and the subscriber, will you please send me two more copies of this issue? You may charge for them if you prefer, so that I can send one to Arizona and replace the one I am giving President Needham.

In a friendly spirit I copy comment in President Needham's letter which I think you will enjoy reading:

> "Perhaps this outfit hasn't learned yet that the Apaches have quit scalping us white folks, and that there are a few educational institutions west of the Mississippi River."

March 1, 1941 LEROY G. HETRICK

—but Some Western Institutions Already Have Courses in Operation

OREGON STATE COLLEGE
CORVALLIS, OREGON

Gentlemen:

. . . I have also received the 25 copies of "Fundamentals of Instrumentation. . . . It now develops that we will have a considerably larger class than expected. If you have them available I should like to have you send ten additional copies. . . . It is my idea to purchase the copies obtained this year personally and loan them to the students. I am quite sure that I would want to use the book again next year.

March 12, 1941 S. H. GRAF, *Professor of*
Air Mail *Mechanical Engineering.*

and Defense Needs Make New Courses Spring Up

THE UNIVERSITY OF SOUTHERN CALIFORNIA
UNIVERSITY PARK
LOS ANGELES

Dear Mr. Rimbach:

The course in Instrumentation will be offered at the University beginning March 17th and will run for 16 weeks meeting one evening per week. The enclosed circular announces the course. Our primary aim in offering this course now is to respond to a pronounced local demand for it among the engineers engaged in the design and construction of defense material in this vicinity. However, we plan to incorporate such a course as a part of our chemical engineering curriculum in the near future. This course is being developed along the lines of possible utility to both groups. I shall be grateful for any material you may have by the way of bibliographies, etc., or anything else you may think useful in this connection.

Please send along a copy of Major Behar's work on Instrumentation. I understand that many sections of it are out of print. I hope it will be possible to adopt his "Fundamentals" as a text—if it is available.

Our library would like to purchase back files of *Instruments*. If you have a set for sale, or know where one could be bought, please advise our Mrs. High of the Library Order Department.

February 28, 1941 H. WATERMAN.

[Enclosure]

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The University of Southern California has been authorized by the U. S. Office of Education to offer the courses listed below under the Engineering Defense Training program. Students should have had at least two years of college training or equivalent experience, and must be American citizens. There will be no fees or tuition, but students will be required to buy their own textbooks. No academic credit will be given.

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* * *

These courses will start about March 17 and are offered with the object of training men for better positions in defense industries. . . .

R. B. STRINGFIELD, *Coordinator,*
Engineering Defense Training Program.

Attention, Readers in Chicago District

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Programs for the April and May meetings are as follows:

April 14—"Optical Measuring Instruments," by Joseph Dauber of The Gaertner Scientific Corporation.

May 12—"Electronic Controls in Industry," by F. Logan of main office of Ward Leonard Electric Company.

All meetings are held on Monday evenings, preceded by a dinner ($1.25) at the Central Y. M. C. A. Auditorium, 19 S. LaSalle Street. Dinner at 6:30. All welcome. Those who cannot come to dinner are invited to come for the talks at 7:45 sharp. For dinner reservations phone Carl Hope, Secretary, at Canal 4100.

One Possible Answer is that it is Not a Trade but a Profession

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Dear Sirs:—

. . . There is another matter on which I would appreciate any information you could send me. That is the standing of a first-class instrument mechanic in comparison with other trades such as machinist, toolmaker, bricklayer, boiler-maker, etc. The comparison I have in mind is from a "field" standpoint and not instrument manufacture.

February 20, 1941 ELIOT A. CRANCH.

BOOK SHELF

Temperature Measurement (2nd Edition). By ROBERT L. WEBER. Edwards Brothers, Inc., Ann Arbor, Mich., 1941. 8¼ × 10¾ inches, x + 171 pages. Price $2.50.

This is by far the most diversified and comprehensive college manual on the subject of temperature measurements that has come to the attention of the reviewer—who has been on the lookout for such books since 1924. Perhaps in some college and during some academic year there was given a course with a fuller and better choice of experiments—but we haven't heard even a rumor of it. (We refer to college courses—not to engineering-school courses, nor to instrument-factory courses. It is pointless to compare oranges, peaches and pears). This Penn State course by Professor Weber (who names also Professors D. C. Duncan and L. T. DeVore as giving it) deserves wider recognition and emulation than it has enjoyed since it was inaugurated some years ago. The exact date of its inception cannot be fixed, for it evolved gradually, but the author's preface mentions that "the experiments have been developed and tested by actual laboratory use over a period of years by an average of a hundred students each year."

Again quoting the preface: "This book presents the substance of a course offered for Juniors by the Physics Department of The Pennsylvania State College. One year of elementary physics is the prerequisite." It is evident that one year of elementary *college* physics is a prerequisite, and that another prerequisite is two years of technical-college mathematics, for without such preparation the student could not work out the problems—problems, by the way, which "educate" in the highest sense of bringing out and developing the latent abilities in a student's mind.

The author has admirably achieved his purpose as stated in the following quotation where we italicize the words that deserve prominence: "It is the purpose of this book to outline an experimental study of the methods of temperature measurement with the theoretical principles necessary for their *appreciation, intelligent use and extension.*"

Mark that last word: "extension." To us it implies that Professor Weber and his as-

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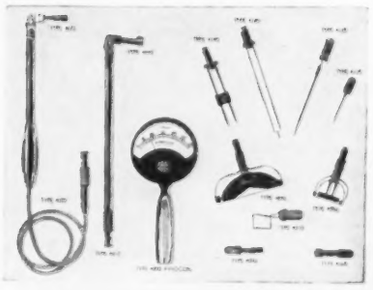

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sociates belong to that dwindling (and therefore more-needed-than-ever) proportion of technical-school professors in whose hearts the sacred spark of The Future has not been quenched by what has been going on these last ten years . . .

Wasn't it in the part of Pennsylvania where Penn State is located that Johnny Appleseed toiled for a future he knew he would not live to see?

All honor to those professors who have the courage (as well as the ability) to sow the seeds of future advances in their branches of science by giving "tough" courses in all the fundamentals of these branches! To be sure, there is a keenly-felt scarcity of instrument *engineers*, due to a scarcity of courses in *industrial* instrumentation, but let us not forget that today's industries, bristling with arrays of recorders and controllers on fifty-foot-long control boards, were made possible by the "pure scientists" of yesterday.

Which is to say that we heartily endorse the other words italicized in the above quotation: "appreciation" and "intelligent use" of the methods of temperature measurement. These are a *sine qua non* for the advancement of this branch of science . . . and for the advancement of the individual worker!

We ought to stop this review right here, but *Instruments* doesn't play favorites. The more important a book is to our readers, the closer it is examined for possible shortcomings.

Again quoting from the preface: "The present book is a revision of a preliminary edition published under the title 'A Manual of Heat and Temperature Measurement' (1939)."

A review copy of that first edition was received at the office of *Instruments* a few months ago, and a few weeks ago the review had at long last been duly completed and was awaiting publication, but . . . how shall we say it? Oh, well, it is such a pleasure to review *this* book that the review of the earlier one has been ordered melted up in the type-metal furnace. That first edition, to put it mildly, was a second-rate ambassador-at-large from a first-rate School of Chemistry and Physics in a first-rate college. Even this second edition—as a specimen of writing and book-making—is unworthy of Dr. Weber's famous course. Not only is the paper binding fragile, not only is lithoprinted typewriting hard on the eyes, not only are the halftone illustrations muddy, but the text shows unmistakable evidences of hasty preparation in spots. We have twice gone through this book page by page, and have read line by line most of Part I (Part II describes the experiments), and we'll wager a good dinner that the word "principal," for example, is spelled incorrectly more often than it is spelled correctly. This is no reflection on the author: it simply means that he worked under severe handicaps and that whoever held the purse-strings (a book, after all, is a manufacturing proposition) was stingy.

Now a few words as to the arrangement. Part I consists of fifteen telegraphically-brief and almost purely mathematical chapters: five chapters on the methods (laws and principles) of temperature measurement; and ten chapters on related subjects such as Heat Transfer, Calorimetry, Thermal Analysis, Elementary Thermodynamics, etc. Some reference tables appear in these chapters because they obviously belong there rather than at the back of the book. These fifteen chapters are not "readable"—for the simple reason that they are not meant to be examples of popularization. The reader who lacks thorough grounding in physics risks making wrong guesses. For example, on page 3, there is a bare mention that the gas coefficient is 1/273 and no mention that this value is true at 0°C. only. Of course, the Penn State Juniors haven't forgotten what they had the year before (and even if they have, they find the gas laws more fully given at the beginning of Part II, in "Experiment 1, Gas Thermometer"). But the ordinary reader does not have that advantage. And so it is throughout Part I: the fundamentals are stated—but stated tersely.

Part II describes and discusses twenty-two experiments including not only thermometry and pyrometry but also calorimetry, thermal analysis, Curie temperature, etc. As we implied in the first paragraph of this review, the choice of experiments is masterly. It was a joy to read some of them—a joy seasoned by regret that the lack of such courses in the engineering schools we attended thirty-odd years ago forced us to learn the newer subjects s-l-o-w-l-y, year by year, the hard way! This book will no doubt be ordered by instrument-department heads and others in charge of evening training courses. To these we recommend putting through requisitions for most of the pieces of laboratory apparatus briefly described in Part II . . . or whatever "reasonable facsimiles" are carried in stock in the nearest laboratory supply house. The industries that foot the bill will soon be repaid many times over by the services of trainees who will have gained "appreciation" and will make "intelligent use" of the Methods of Temperature Measurement. —M. F. BEHAR

Reports on Progress in Physics. Volume VI. J. H. AWBERY, General Editor for THE PHYSICAL SOCIETY. Taylor & Francis, Ltd., London, 1940. Cloth, 7 × 10 inches, vi + 434 pages. Price 20*s*. (or $5 according to order blank for U. S.)

A new General Editor and a new publisher, but the same binding and typography; and—what is more important—the same superlative quality of content, arrangement, presentation, style and other requisites.

In fact, high as were the standards set by Dr. Allan Ferguson, Dr. Awbery has surpassed them. This is evident as one first thumbs through the just-received book and discovers that there are no fewer than eight inserted plates, excellently printed on high-grade coated paper on which reproduction of spectrographs, Zeeman patterns, etc., show fine details as well as did the originals.

Another little touch which, to the trained eye, speaks volumes, is the relatively large number of references to private communications. This means that the editor is an efficient executive, getting his contributors to make thorough surveys and fill in the gaps by dint of diligent search and patient, time-consuming correspondence.

The reviewer has again made a quantitative analysis of this book (as he did of previous ones) and for the same reason, namely, that the table of contents gives only the main headings. The following, therefore, is a detailed list giving not only the 22 Reports but the topics, numbers of pages and numbers of references in each report.

The physics of stellar interiors and stellar evolution. By H. A. Bethe and R. E. Marshak: 15 p., 26 refs.

Induced radioactivity. By (the late) H. J. Walke—§1. Introduction, ½ p., 2 refs. §2. The range-energy relation for β-rays, 1 p., 2 refs. §3. The Continuous β-ray spectrum, 4 p., 13 refs. §4. Nuclear K-electron capture, 2 p., 19 refs. §5. Nuclear isomerism, 3½ p., 17 refs. + 51 classified refs. under "List of Isomers." §6. Induced radioactivity by nuclear excitation, 2 p., 11 refs. §7. Element 43, 2 p., 8 refs. §8. Induced radioactivity by hard γ-rays (nuclear photodisintegration), 2 p., 4 refs. §9. Induced radioactivity by the fission of uranium and thorium nuclei, 10 p., 43 refs.

Separation of isotopes. By H. C. Urey: 27 p., 118 refs.

The Meson. By R. Peierls—Mesons in cosmic rays; Theory of free mesons; Interaction terms; Other applications of the theory; Collision problems: 15 p., 82 refs.

The production and measurement of short-wave radiations. By G. W. C. Kaye, G. C. Bell, W. Binks and W. E. Perry—§1. Introduction, 1 p. §2. High-voltage apparatus,

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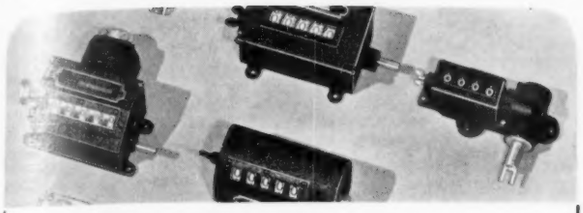

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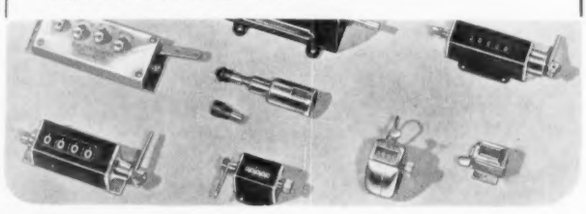

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The cyclotron and some of its applications. By W. B. Mann: Magnetic resonance acceleration; Energy of emergent ion beam; Effect of relativity; Magnetic and electrostatic focussing; The radio-frequency dee voltage supply; The ion source; Some applications. 10 p., 63 refs.

Spectroscopy. Editor, W. Jevons: I. The spectra of supernovae. By A. Hunter: 8 p., 12 refs.; II. Some recent developments in the Zeeman effect in atomic spectra. By H. E. White: Introduction; Stronger sustained magnetic fields; Impulse magnetic fields; The Zeeman effect of hyperfine structure; Quadratic Zeeman effect: 16 p., 12 refs.; III. The magnetic effect in diatomic spectra. By F. H. Crawford: Introduction and historical résumé; Behavior of molecules in a magnetic field; Hund's limiting molecular coupling types; Magnetic splitting of energy levels in Hund's coupling cases; Comparison of theory with experiment: 18 p., 74 refs.

The luminescence of solids. By J. T. Randall and M. H. F. Wilkins: 11 p., 52 refs.

Reactions in solids. By N. F. Mott: Diffusion and electrolytic conduction in solids; Motion of electrons in polar crystals; Ionic crystals of non-stoichiometric composition; Formation of a new phase in solid reactions —oxidation, tarnishing reactions; Reactions involving precipitation, reduction; Influence of strains on precipitation, Nuclear formation: 25 p., 42 refs.

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Heat. By R. W. Powell: Measurement of high temperature in industry (F. H. Schofield, co-author): 7 p., 45 refs.; Temperature measurements at normal and low temperatures: 3 p., 12 refs.; Hygrometry: 3 p., 12 refs.; Heat transfer to boiling liquids: 2 p., 9 refs.; Condensation, evaporation and convection: 3 p., 18 refs; Radiation: 3 p., 8 refs.; Specific and latent heat determinations: 4 p., 25 refs.; Conduction of heat: 4 p., 14 refs.; Thermal expansion: 3 p., 15 refs.

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X-rays and crystals. Editor, J. Monteath Robertson: I. Organic structures. By J. M. Robertson: 6 p., 35 refs.; II. The structures of silicates. By W. H. Taylor: 8 p., 85 refs.; III. The examination of ternary alloy systems by x-rays. By H. Lipson: 7 p., 18 refs.; IV. Order-disorder phenomena in alloys. By E. T. Goodwin: 9 p., 27 refs.

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Impedance networks. By R. S. Rivlin: 13 p., 25 refs.

The measurement of capacitance. By N. F. Astbury: 7 p., 51 refs.

Dielectric breakdown in solids. By H. Fröhlich: 20 p., 36 refs.

The teaching of physics in technical institutions. By D. Owen: 4 p.

Although the preceding annual volumes were not devoid of mentions of applications in industry, this one seems to have more—not only in that more industrial subjects have been assigned to be written up as sections of reports, but also in that when this was not the case, some authors had industrial possibilities in mind.

No physical research laboratory is completely equipped if it lacks this volume and its precursors. But the lack of its precursors should not deter anyone from putting in an order for *this* treasure of conveniently-arranged current information. And, above all, don't hesitate on account of rumors of delays: English technical weeklies are being regularly received here in Pittsburgh within three weeks after publication—sometimes in sixteen days. There will always be an England!

—M. F. BÉHAR

Chambers's Technical Dictionary. Edited by C. F. TWENEY and L. E. C. HUGHES. The MacMillan Co., New York, 1940. Cloth, 5½ × 8½ inches, viii + 957 pages. Price, $5.

This is the first printing of what might be called the first "simple-yet-comprehensive" technical dictionary in the English language. It is impossible for any review to convey a precise idea of the scope of such a work without quoting a relatively large number of listings (enough to fill one of these columns in *Instruments*) and critically discussing the definitions . . . with the aid of a few dozen fellow-reviewers. This reviewer began his task by attempting to do just this single-handed, but he soon realized that he was unconsciously veering from his aim which is, of course, to review this book for the readers of *Instruments* only.

No doubt the reader has already seen some of the advertisements, and received as many copies of the publishers' prospectus as the number of societies to which he belongs. In general, the reviewer finds that the publishers' advertisements and prospectus do not contain exaggerations. It really is "an invaluable aid for . . . manufacturers, . . . technicians," etc.

We find it necessary here to mention that the editors are Englishmen—apparently writing for British technical men. The editors have had the collaboration of twenty-seven contributors (making twenty-nine contributors) and the proportion of Americans —as far as we can discern—is zero. The American publishers assert, in their prospectus, that "an important feature of this great Technical Dictionary is the inclusion of both the English and American terminology where these differ from each other. Special care has been taken to do this, and leading American authorities have been consulted."

These American authorities (nowhere named) evidently did not include any authorities on industrial measuring instruments, meters, automatic controllers, automatic inspection and testing, etc. But this should not lessen the value of this book to *Instruments* readers, for they do not expect to find in a general technical dictionary such terms as thermometric lag (or even lag in the general temporal sense), tube-system, decade box, reset, droop-corrector, asymptotic reset, phasing-out, prover (for meters), proving-ring (for testing machines), and dozens if not hundreds of other terms we use in our—let's call it jargon.

On the other hand, both the preface and the publishers' prospectus are too modest with regard to the inclusion of terms from *new* branches of science and technology. The experts in radio, television, acoustics, sound recording, aeronautics, etc., evidently kept on sending their terms and definitions until late in 1939. The "pure science" contributors, however, seemed to have been somewhat slower—or perhaps over-cautious —as evidenced by the omission of "meson," "mesotron," etc.; also of such terms as "Coriolis force" which are not newly-coined but which are lately coming into frequent use in the vernacular in certain branches of technology.

Perhaps these omissions are not inadvertent. Perhaps the editors carefully refrained from including terms which they did not believe to have "arrived." After all, it may be that if the editors had not exercised their right of selection, this dictionary would have turned out to be twice its present size and—naturally—twice its low price of $5. This is a low price indeed for nearly a thousand pages—for more than 50,000 entries. Figure it out either way!

This review cannot be closed without mentioning the nine useful appendices: chemical elements, the vegetable kingdom, the animal kingdom, etc., some tables occupying several pages. Nor without mentioning the strong paper, clear printing and durable binding.

—M. F. BÉHAR

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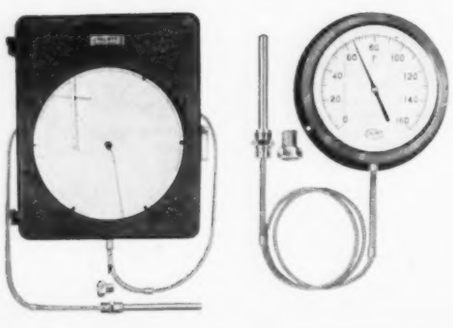

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I-72 **General Radio "Experimenter."** Feb. 1941 issue, 8 pages, contains articles on ultra-high-frequency signal generator, returning instruments for repair and chart for use with type 516-C radio-frequency bridge. General Radio Co., 30 State St., Cambridge, Mass.

I-73 **Cathode-ray Oscillograph.** Bulletin, 6″ × 9″, 8 pages, describes and illustrates Type 208 oscillograph with distortionless input-attenuator, newly developed amplifier circuit among its features. Allen B. DuMont Labs., Inc., 2 Main Ave., Passaic, N. J.

I-74 **Water-cooled Aftercoolers.** Bulletin H-807-B1, 8″ × 10½″, 2 pages, describes and illustrates type H aftercooler for vertical air compressors developed for preventing the presence of moisture and vapor in air lines such as in operating of laundry presses, paint sprayers, control instruments, etc. Worthington Pump & Machinery Corp., Harrison, N. J.

I-75 **Controlled-current Test Set.** Bulletin 1053, 8½″ × 11″, 4 pages, covers Autelco type 1 test set which passes a predetermined and accurately controlled flow of electrical current for the purpose of testing and adjusting relays. American Automatic Electric Sales Co., 1033 W. Van Buren St., Chicago, Ill.

I-76 **Oil Circuit Breakers.** Catalog 3940, 8½″ × 11″, 4 pages, describes and illustrates type MS-2 subway oil circuit breaker non-automatic, for wall mounting in subways, manholes, or other places where total submersion is possible. Furnished in capacities of 200 and 400 amperes, in 2 or 3 poles, 7500 volts. Roller-Smith Co., 1766 W. Market St., Bethlehem, Pa.

I-77 **"Xactopack."** Bulletin, 8⅜″ × 10¾″, 4 pages, shows new model of gasoline-engine-powered "Xactopack" Figure 385, available optionally with explosion-proof electric motor. S. F. Bowser & Co., Inc., Fort Wayne, Ind.

I-78 **Briquetting Press.** Leaflet, 8½″ × 11″, 2 pages, describes and illustrates specimen press used to briquette powders, borings and milled chips of metals and many powdered and granular metallic or non-metallic materials into tablets, which then are placed in spark or arc gap of spectrograph. Harry W. Dietert Co., 9330 Roselawn Ave., Detroit, Mich.

I-79 **Automatic Continuous Boiler Blowoff Equipment.** Bulletin No. 2391, 8½″ × 11″, 8 pages, tells why blowoff is necessary; points out shortcomings of old or intermittent controls; discusses several typical arrangements of modern continuous blowoff equipment. Describes various types of heat exchangers, flash tanks and other developments. The Permutit Co., 330 W. 42nd St., New York City.

I-80 **Thermoswitches.** Catalog Sections, 8⅜″ × 10⅞″, 12 sheets, describe and illustrate cartridge, block head, hex head, flange head and submersion types of thermoswitches. Fenwal Inc., Ashland, Mass.

I-81 **Cornell-Dubilier "Capacitor."** Vol. 4, No. 8, 16 pages, contains articles entitled "Analyzing Radio Noises"—Part III and "Filter Design Calculator" the latter by Arthur H. Halloran, Editor, Amateur Radio Defense. Cornell-Dubilier Electric Corp., Hamilton Blvd., South Plainfield, N. J.

I-82 **Tellurium Portable Cable.** GEA-1918B, 8″ × 10½″, 8 pages, describes and illustrates portable cable for all portable electric machinery, gives current-carrying capacities and physical data; also lists molded terminals and couplers. General Electric Co., Schenectady, N. Y.

I-83 **"Bakelite Review."** Jan. 1941 issue, 8½″ × 11″, 24 pages, contains articles "Automatic Compression Molding Is Here", "Consideration of Plastics in Airplane Design" and other articles and items on applications of Bakelite plastics. Bakelite Corp., 30 East 42nd St., New York City.

I-84 **Recording Gravitometer.** Folder, 8¼″ × 10¾″, describes and illustrates Ac-Me gravitometer—contains no rotating parts which might become worn out and operates on the principle of weighing a volume of gas in comparison with the weight of an equal volume of air. The Refinery Supply Co., 621 E. Fourth St., Tulsa, Okla.

I-85 **"New-Matic" Remote Transmission.** Catalog No. 9400, 7⅞″ × 10½″, 24 pages, describes and illustrates system applied to indicating, recording and control of temperature, pressure, flow and liquid level, featuring matched bellows. Brown Instrument Co., Wayne & Roberts Aves., Philadelphia, Pa.

I-86 **Temperature Control.** Bulletin E, 8½″ × 11″, 4 pages, describes and illustrates "Comfortrol," a humidity-compensated thermostat for application to any type of heating equipment—oil burner, gas burner, stoker, blower, etc., or to any type of summer cooling equipment. Julien P. Friez & Sons, Baltimore St. and Central Ave., Baltimore, Md.

I-87 **Flow Indicator.** Bulletin, 8½″ × 11″, 4 pages, covers indicator for water and other free flowing liquids to indicate the rate of flow of hot dirty blowdown from steam boilers. Henszey Co., Watertown, Wis.

I-88 **Ground Resistance Tester.** Bulletin 251, 8½″ × 11″, 4 pages, describes and illustrates new "Model 251 Vibroground" designed for testing resistance to earth of ground rods and is of the synchronous self-rectifying type. Associated Research, Inc., 431 So. Dearborn St., Chicago, Ill.

I-89 **Aerovox "Research Worker."** Vol. 12, Nos. 7 and 8, 8½″ × 11″, each 4 pages, contain respectively articles entitled "Measuring Distortion in Audio-Frequency Amplifiers" and "Receiver Tuned Circuits." Aerovox Corp., New Bedford, Mass.

I-90 **Plaster Tester.** Bulletin, 8½″ × 11″, 2 pages, describes and illustrates "Kaydel" plaster tester for determination of moisture. Instrument dimensions 2⅞″ × 1¾″ × 5½″; weight 20 oz., extension contactor with 4½ ft. cable is available as accessory. Hart Moisture Gauges, Inc., 126 Liberty St., New York City.

I-91 **Combined Liquid Level and Pressure Controller.** Bulletin PW6, 8½″ × 11″, 4 pages, covers new "PW" and "PWD" controllers which maintain water level and air volume automatically in pressure tanks and prevent tank from becoming waterlogged or air bound; permit utilizing maximum capacity of tank. Water Level Controls Co., 2255 University Ave., St. Paul, Minn.

I-92 **Dial Test Indicator.** Bulletin, 8½″ × 11″, 4 pages, describes and illustrates new indicator which utilizes a lever arm instead of the usual rotating multiple gear and pinion trains. A few common applications are shown. George Scherr Co., 128 Lafayette St., New York City.

I-93 **"How To Maintain D-c. Motors."** Bulletin GEA-3488, 8″ × 10½″, 4 pages, covers selection, inspection and servicing, overhauling and repairs, etc.; includes trouble correction chart for d-c. motors. General Electric Co., Schenectady, N. Y.

I-94 **Fuses and Mountings.** Bulletin 740, 8½″ × 11″, 2 pages, describes and illustrates 3AG fuses—250 volts, hinged type mounting for 3AG fuses and panel pull safety fuse mounting for 4AG fuses, also low voltage tattelite tester for range of 3 to 25 volts. Littelfuse, Inc., 4757 Ravenswood Ave., Chicago, Ill

I-95 **"Care and Operation of Portable Precision Lathe Grinders."** Booklet, 8½″ × 11″, 14 pages, gives general description of the grinding process, some of the problems of precision grinding and some of the typical grinding setups. The Dumore Co., Racine, Wis.

I-96 **Telephone Traffic Recorder.** Circular 1643, 8½″ × 11″, 8 pages, describes and illustrates traffic recorder with pen magnets for operation on 48 volts, d-c, driving motor for 110-v., 60-cycle a-c, and is supplied complete with gears and cams for paper speeds of 1″ and 25″ per minute, with time pulses of 6 seconds and 1 second, respectively. American Automatic Electric Sales Co., 1033 W. Van Buren St., Chicago, Ill.

I-97 **Engraving Machine.** Catalog, 6″ × 9″, 8 pages, describes and illustrates versatile pantograph machine adaptable to many lettering tasks associated with experimental work as well as the routine production of panels, nameplates and small parts. Mico Instrument Co., 10 Arrow St., Cambridge, Mass.

I-98 **Potentiometer Pyrometers.** Catalog No. 1104, 7⅞″ × 10½″, 36 pages, covers indicating, recording and control pyrometers, gives illustrations of typical installations; also lists Radiamatic pyrometer, auxiliary switches, control accessories, multiple key switches, etc. Brown Instrument Co., Wayne & Roberts Aves., Philadelphia, Pa.

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I-100 **Induction Motors.** Bulletin GEA-978B, 8" × 10½", 4 pages, covers high-speed motors for direct connection—applications include boiler-feed pumps, oil-refinery pumping, pipeline pumping, centrifugal compressors and water-supply pumping. General Electric Co., Schenectady, N. Y.

I-101 **Signal Generators.** Sheet, 8½" × 11", 1 page, describes Models 54 and 65 standard signal generators — 100 kilocycles to 25 megacycles in six coil ranges with push-button switching, worm driven tuning condenser for long scale spread, 18 ft. on each coil range. Measurements Corp., Boonton, N. J.

I-102 **Liquid Level Gages.** Catalog 1015, 8" × 10½", 20 pages, describes and illustrates float, pressure-bulb, pressure, air-bubbler, counterpoise and differential pressure types water and liquid level gages for all types of applications, including the measurement and automatic control of liquids in open, as well as in closed vessels where the surface of the liquid is under static pressure. The Bristol Co., Waterbury, Conn.

I-103 **Barber-Colman "Motor Notes."** Issue dated Feb. 6, 1941, describes applications of "Barcol" motors in a number of industries. Barber-Colman Co., Rockford, Ill.

I-104 **Temperature and Pressure Controllers.** Catalog 2500, 5⅛" × 7⅜", 84 pages, describes and illustrates complete line of self and air operated controllers, including price list. American Schaeffer & Budenberg Instrument Div., Manning, Maxwell & Moore, Inc., Bridgeport, Conn.

I-105 **Resistance Decades.** Bulletin No. 825, 8½" × 11", 4 pages, describes and illustrates "Akra-Ohm" resistance decades, unmounted decade resistances, wire wound resistors, rotary instrument switches, binding posts and decade potentiometer. Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa.

I-106 **Ironcase Meters.** Catalog EG-40, 8½" × 11", 26 pages, describes and illustrates sewage gas meters, observation meters, oxygen meters, curb meters, volume and pressure gages, base pressure indexes and base volume indexes. American Meter Co., 60 E. 42nd St., New York City.

I-107 **Wall Calendar.** Varied problems encountered in modern industrial processes are presented in a humorous vein by a series of cartoons. Also included is helpful engineering information in the form of charts such as fuel gas analysis checking charts, steam leakage chart, psychrometric chart, etc. Brown Instrument Co., Wayne & Roberts Aves., Philadelphia, Pa.

I-108 **Illuminator-magnifier.** Folder, 3¾" × 8½", 6 pages, describes and illustrates "Magni-Master" designed for industrial inspection and precision work. Illumination said to duplicate daylight conditions, eliminating eye-fatigue. Models are available in hand units, stand units or fitted for attachment to special equipment. Mizzy, Inc., 105 East 16th St., New York City.

I-109 **Test Instruments.** Bulletin, 7⅛" × 10⅛", 8 pages, describes and illustrates utility tester, dynarometer, channel-analyzer, signal generator, Model 1250 multi-meter, Model 1240 tube tester and set tester combining Models 1240 and 1250. Superior Instruments Co., 136 Liberty St., New York City.

I-110 **Industrial Capacitors.** 1941 Edition of Manual, 8½" × 11", 28 pages, contains practical application data and listings of electrolytic and oil motor-starting capacitors. Introduces numerical cross-section of maker's types with such data as a-c. voltage, actual range, nominal range, dimensions, illustrations, list price and corresponding parts numbers of motor manufacturers. Aerovox Corp., New Bedford, Mass.

I-111 **Hot Process Water Conditioning.** Publication 3000, 8½" × 11", 48 pages, describes and illustrates softeners for removal of hardness, silica and other scale-forming material from boiler feed and industrial process waters. Contains 9-page appendix of feed-water chemistry, in addition to heat balances, flow diagrams, two-color construction drawings and engineering tables and charts. Cochrane Corp., 17th & Allegheny Ave., Philadelphia, Pa.

I-112 **Aerovox "Research Worker."** Vol. 12, Nos. 9 & 10, contain parts 1 and 2 of article entitled "Modern Trends in Service Test Equipment." Aerovox Corp., New Bedford, Mass.

I-113 **Bodine "Motorgram."** Vol. 21, Nos. 1 and 2, contain respectively feature articles entitled "Diagnosing Troubles of Small Motors" and "Designing Small Motors for Quiet Operation—Part I." Bodine Electric Co., 2250 W. Ohio St., Chicago, Ill.

I-114 **Precision Balances.** Catalog 4540, 8½" × 11", 8 pages, describes and illustrates Models B, C and D balances for determination of the weight of small objects or materials where a number of weighings of approximately the same value must be made, and surface tension balance designed for measuring the surface tension of liquids. Roller-Smith Co., 1766 Market St., Bethlehem, Pa.

I-115 **"The Ohmite News."** Feb. 1941, 2 pages, lists various stock rheostats, resistors, tap switches and chokes and item on resistors lugs for diverse applications. Ohmite Mfg. Co., 4835 Flournoy St., Chicago, Ill.

I-116 **Abraser.** Bulletin 4012, 7¾" × 10½", 6 pages, describes and illustrates testing machine for evaluating resistance of surface finishes to rubbing abrasion. Range of application includes nearly all paint, lacquer, electroplated and plastic surfaces. Textile fabrics can be tested by using the supplementary equipment furnished with the instrument. Lists shear-hardness attachment also. Taber Instrument Co., North Tonawanda, N. Y.

I-117 **Velocity Power Gage Tester.** Bulletin No. TA-6, 8½" × 11", 1 page, describes and illustrates device designed for safely testing gages used in conjunction with compressed gas storage cylinders, to determine their ability to withstand sudden applications of surge pressure encountered under service conditions. Mine Safety Applicances Co., Braddock, Thomas & Meade Sts., Pittsburgh, Pa.

I-118 **Audio Signal Generators.** Bulletin T-101, 8½" × 11", 2 pages, covers Models 205-A and 205-AG generators for general laboratory applications supplying a known voltage as well as a known frequency at the voltage at the commonly used impedance levels. Particularly suitable for gain measurements because no auxiliary apparatus is required. Hewlett-Packard Co., 481 Page Mill Rd., Palo Alto, Calif.

I-119 **Time Standard.** Bulletin 2089AL, 8½" × 11", 2 pages, describes and illustrates time standard consisting essentially of an electronically driven 500-cycle tuning fork and an electrically isolated pickup and power amplifier as the source of the output power. American Instrument Co., 8010 Georgia Ave., Silver Springs, Md.

I-120 **Liquid Level Controller.** Sheet, 8⅝" × 10½", 1 page, announces new method for liquid level control which transmits float motion through the wall of a pressure vessel without the use of stuffing glands or any electrical method. Moore Products Co., 3629 N. Lawrence St., Philadelphia, Pa.

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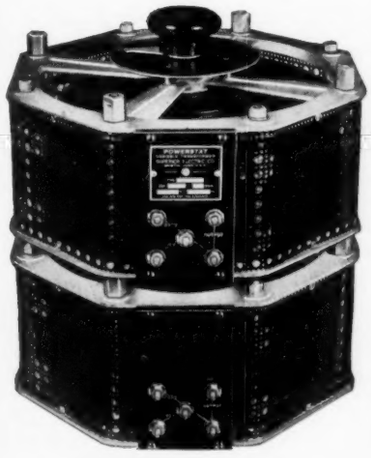

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